MAY 1955

Journal

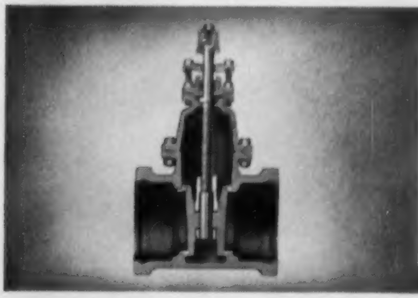
VOL. 47 • NO. 5

AMERICAN WATER WORKS ASSOCIATION

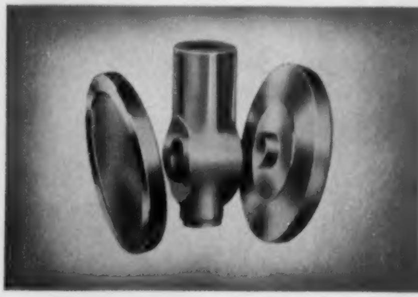
In this issue

R. D. WOOD GATE VALVES PROVIDE POSITIVE FLOW CONTROL AFTER YEARS IN THE LINES

Here's what the R. D. Wood Gate Valve looks like from the outside — rugged, simple, streamlined. It is built for generations of dependable service in the lines. Available with all pipe connections, including mechanical joint.



Strip it down to a sectional view and you can see why interruptions in service are rare. There's virtually nothing to go wrong — none of the complicated small parts that fail in an emergency because sediment and scale render them inoperable.



Bring the R. D. Wood Gate Valve down to its essentials and you have the spreader and two discs. Rising or descending, discs are free to revolve completely, thus distributing wear evenly. In closing, discs are fully lowered before spreading action begins. Fully opened, components move out of the water way, providing full pipe capacity.

R. D. WOOD COMPANY

Public Ledger Building, Independence Square

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Manufacturers of Mathews Hydrants and "Sand-Spun" Pipe (centrifugally cast in sand molds)

Journal

AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y. • Phone: MUrray Hill 2-4515

May 1955

Vol. 47 • No. 5

Contents

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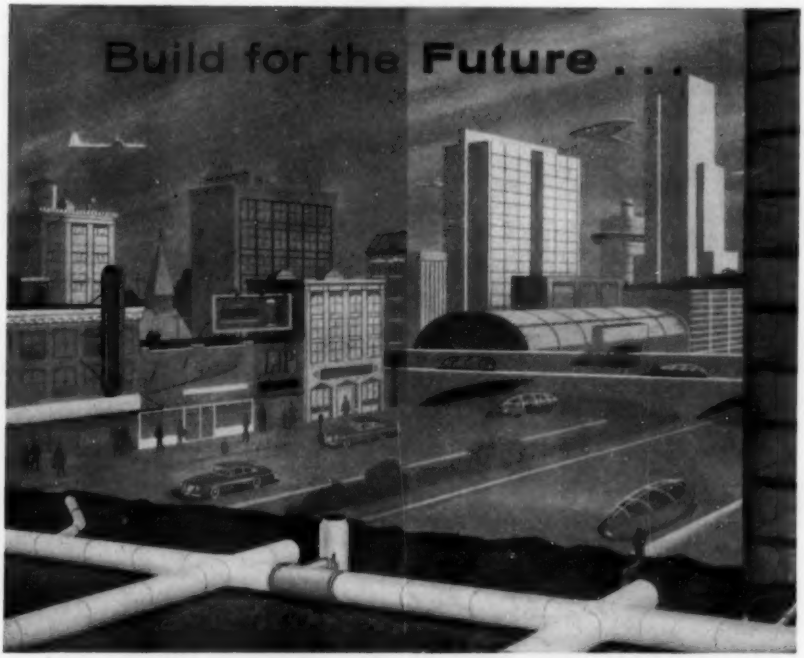

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Coming Meetings

AWWA SECTION

May 19–21—Pacific Northwest Section at Hotel Chinook, Yakima, Wash. Secretary, Fred D. Jones, Dist. Supervisor, Rm. 305 City Hall, Spokane, Washington.

OTHER ORGANIZATIONS

May 30–Jun. 1—42nd National Rivers and Harbors Congress, Mayflower Hotel, Washington, D.C.

Jun. 6–10—North Carolina Water Works Operators Assn. Short Course, Univ. of North Carolina School of Public Health, Chapel Hill, N.C.

Jun. 13–Jul. 1—Short Course on "Ecology of Fresh Waters" at Linesville, Pa., sponsored by Univ. of Pittsburgh. Pittsburgh, Pa.

Jun. 26–Jul. 1—American Society for Testing Materials, Atlantic City, N.J.

AWWA ANNUAL CONFERENCE

Conrad Hilton Hotel, Chicago   June 12-17, 1955

Papers Scheduled for Presentation

Monday, Jun. 13

Merits, Defects, and Performance of Monobed and Two-Bed Demineralizing Systems ...... H. E. Bacon, L. G. Von Lossberg & S. T. Powell

Boiler Water Suspended Solids—Their Significance, Identification, and Control .... S. K. Adkins & B. J. Wachter

Corrosion Problems in Small Heating Boilers .... H. F. Hinst

Effect of Various Types of Water on Nonferrous Metals.................... Lee Streicher

Problems in Estimating Fluorides in Water .... H. P. Kramer

Biological Infestation of Purified Water—Panel Discussion .... M. P. Crabill, J. K. G. Silvey & W. T. Ingram

Effect of Disinfection Dosages of Chlorine on New Water Mains .... William Yegen

Regional Water Supply Planning for North Central Ohio .... Paul Belcher

Discussion .... Wendell R. LaDue

Our National Water Resources Policy .... Clarence A. Davis

1955 State Legislation Concerning Water Resources—Panel Discussion .... *Led by* Stephen W. Bergen; C. H. Capen, G. S. Rawlins, C. H. Bechert, T. W. Thorpe, M. B. Cunningham & C. M. Hoskinson

Tuesday, Jun. 14

Development of a Fresh-Water Pressure Barrier to Sea Water Intrusion in Southern California .... Finley B. Laverty

Recharge Operations of the Upjohn Company at Kalamazoo .... W. H. Sisson

Streams Plus Wells Make Economical Industrial Supply .... R. D. Wilson

Discussion .... Clifford Fore

Unique Features in Water Treatment Plant Design—Panel Discussion .... *Led by* H. O. Hartung; William Aultman, C. M. Bach, Marshall Houghn & Thomas M. Riddick

(*Continued on page 8*)


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Coming Meetings

(*Continued from page 6*)

Recording Instrumentation in Water Treatment Plants .... Oscar Gullans
Effects of Detergents on Water Treatment .... J. C. Vaughn
Discussion .... Charles D. Gates
The Magnitude and Treatment of Nuclear Reactor Wastes .... W. A. Rodger
General Review—Studies of Water Treatment Methods to Prevent Radioactive Pollution ... H. Gladys Swope
Instrumentation for Radioactive Pollution Studies .... H. E. Pearson
1955 Studies of Radioactive Fallout .... Rolf Eliassen & Robert A. Lauderdale
Symposium—Controlled Draft From Reservoirs
New York Metropolitan System .... Edward Clark
Johnstown Plant, Bethlehem Steel Corp. .... Angus Henderson & A. S. Toth
Equating Surface and Underground Storage .... R. A. Hill
Water Management—Another Necessity in Modern Industry .... K. S. Watson

Wednesday, Jun. 15

The Problem of the Suburbs and Public Services—Panel Discussion
Introduction .... Abel Wolman
Your Government's Stake in the Provision of Adequate Community Facilities .... John C. Hazeltine
The Public Service Commission's Viewpoint .... O. P. Deuel
The State Sanitary Engineer's Viewpoint .... W. F. Shephard
The Fire Protection Problem .... Kenneth Carl
Resume .... Abel Wolman
Design of Cement-lined Steel Pipe .... E. S. Cole
Electrical Inspection of Coatings on Steel Pipe .... Mark Davidson
New Developments in Tests of Coatings and Wrappings .... G. E. Burnett & Paul W. Lewis
Effects of Physical Environment on Water Mains .. W. D. Hurst, R. F. Legget & A. Baracos
Chromium and Cadmium in Water .... Clarence F. Decker
Effect of Water Treatment on Water Mains .... A. M. Buswell
Public Health Service Research Grants in the Area of Environmental Health and Water Supply .... Irving Gerring
Report of AWWA Committee on Water Works Research Needs .... Martin E. Flentje
Selecting Adequate Electrical Switching Equipment .... E. O. Potthoff & N. L. Hadley
Maintaining Electrical Controls at High Efficiency .... J. P. Kesler
Modernizing Chicago's Pumping Stations .... O. B. Carlisle & J. L. Weeks
Progress in Tunnel Construction for Central District Filtration Plant ..... George S. Salter

Thursday, Jun. 16

A Forecast of Metropolitan Chicago's Water Needs .... L. R. Howson
Water Supply Industry Safety—US Labor Department Survey ..... George R. McCormack
A Successful Safety Program .... J. W. McFarland
Discussion .... Thomas Allen
Modernizing the Management of Chicago's Water Department .... J. W. Jardine
Easements for Pipelines .... Burton S. Grant
Pumping Stations in Residential Areas—Joint Discussion
Long Island .... Peter Ley
California .... L. A. Hosegood
The Solution Effects of Water Upon Cement and Concrete Linings of Water Mains .... M. E. Flentje & R. J. Sweitzer
Discussion .... P. S. Wilson
A Fifteen-Year Exposure Test on Three Types of Distribution Pipe .... M. J. Shelton
Ready-to-Serve Charges for Private Fire Protection .... L. R. Hanson
Service Charges for Air Conditioning .... W. V. Weir
The Lawn Sprinkling Load—Panel Discussion .... Angus Henderson, E. F. Tanghe, L. S. Finch & M. P. Hatcher
Getting Your Customers on Your Team .... Joseph S. Rosapepe

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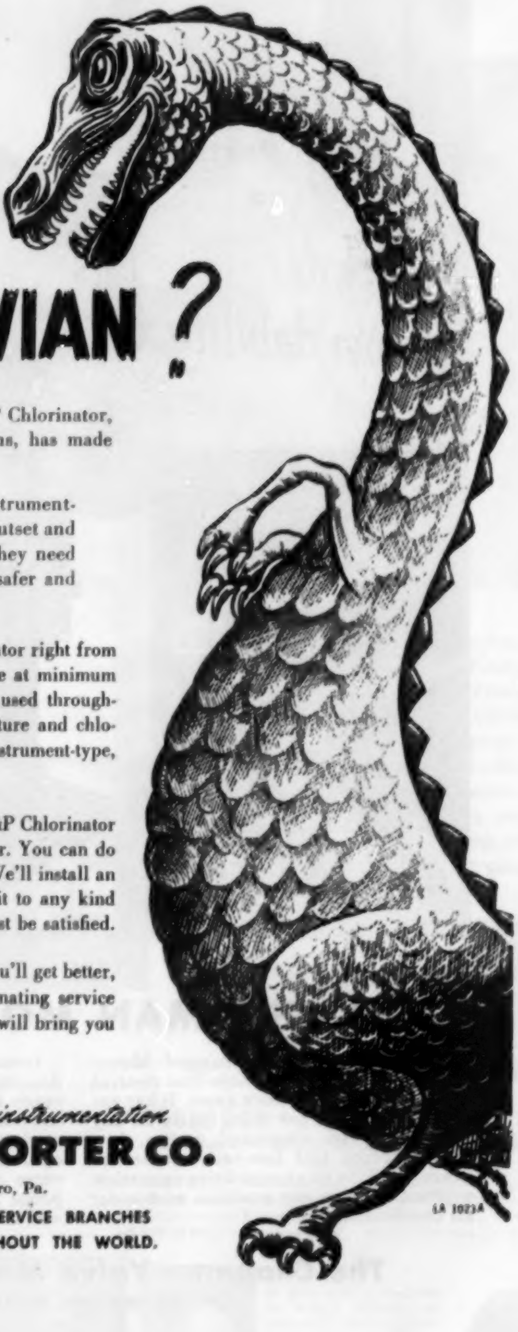

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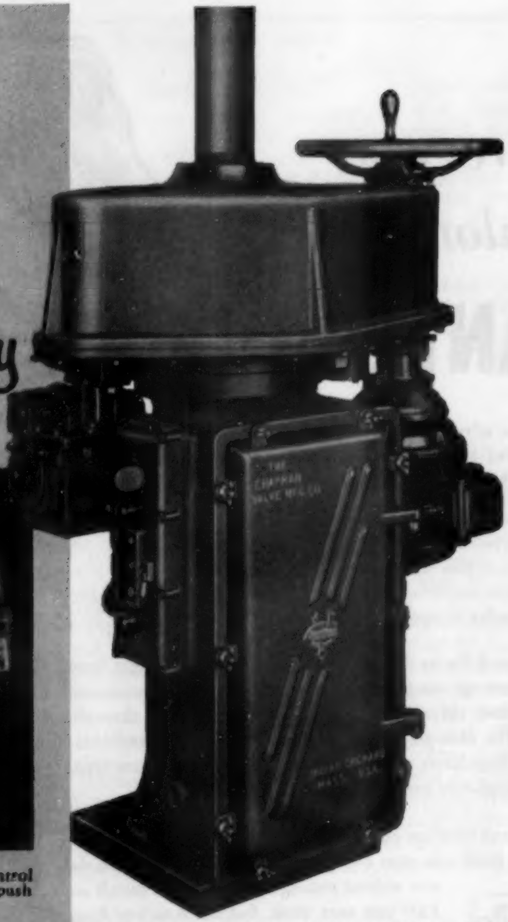

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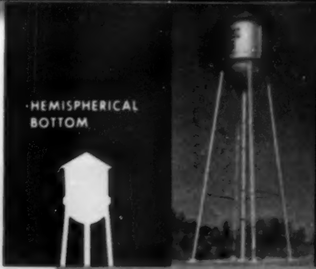

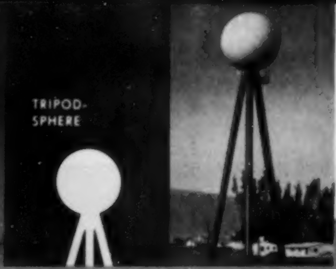

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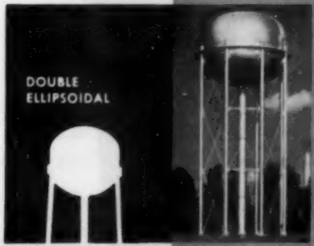

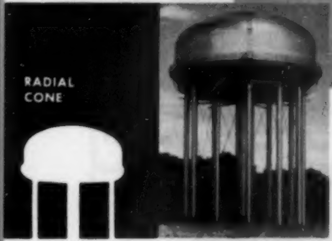

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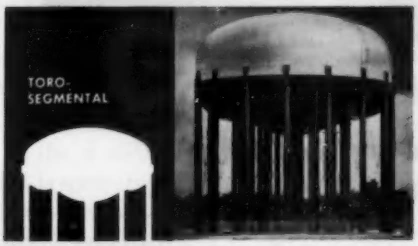

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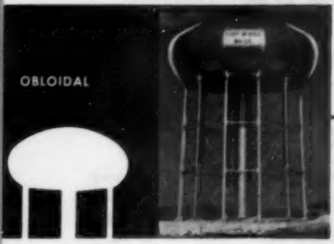

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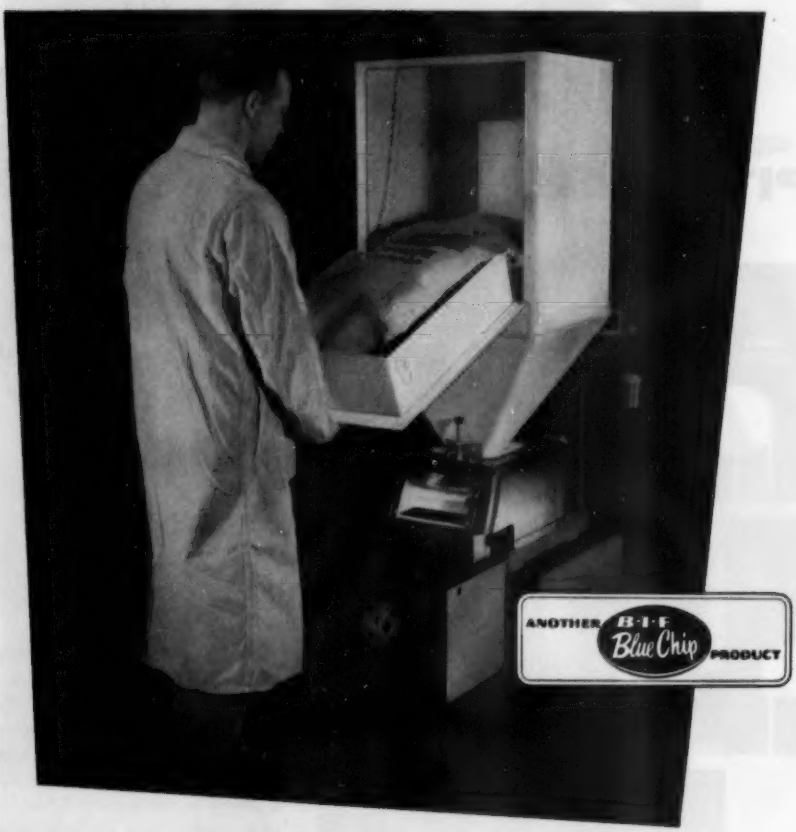

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for
RAPID SAND FILTER

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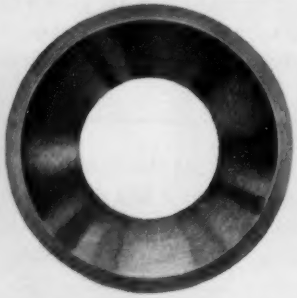

"CENTURY"® PIPE

The smooth bore of "Century" Asbestos-Cement Pipe means less resistance to water flow and, consequently, lower pumping costs. Formed on a smooth steel mandrel, the pipe has an interior surface to match. The Williams and Hazen Constant "C" is conservatively placed at 140 for "Century" Asbestos-Cement Pipe. Being non-metallic, it cannot tuberculate.

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9. LIGHT WEIGHT
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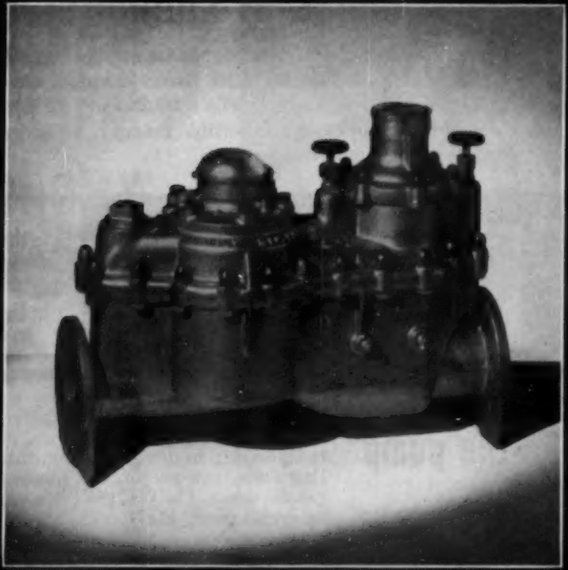

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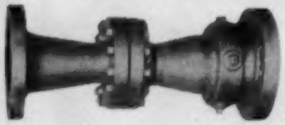

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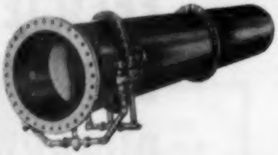

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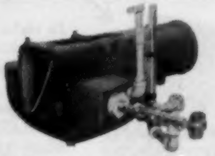

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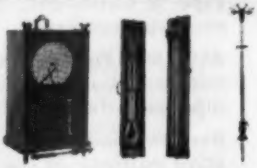

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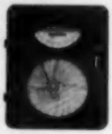

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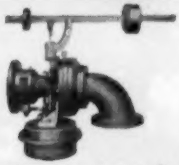

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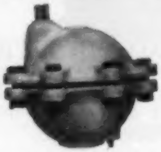

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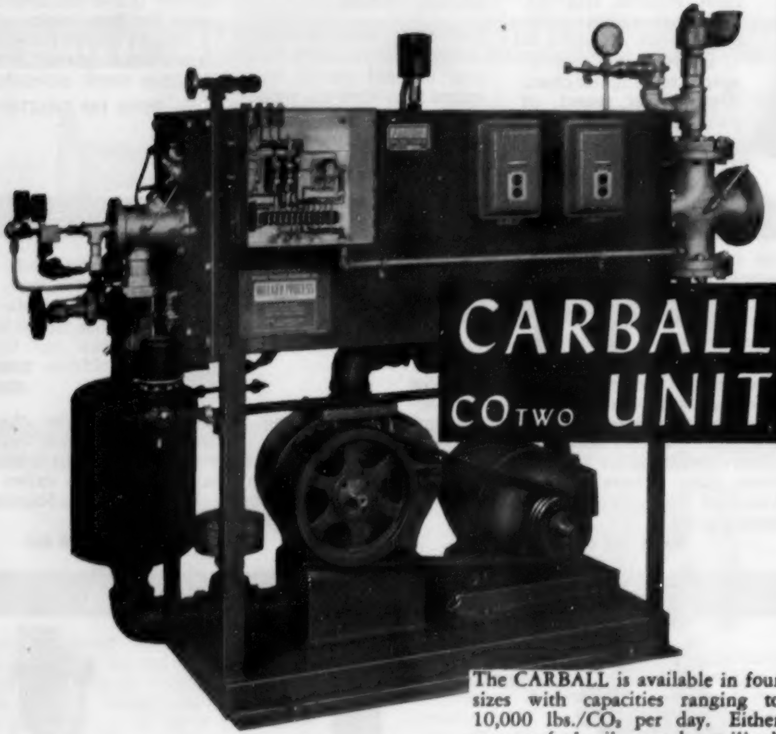

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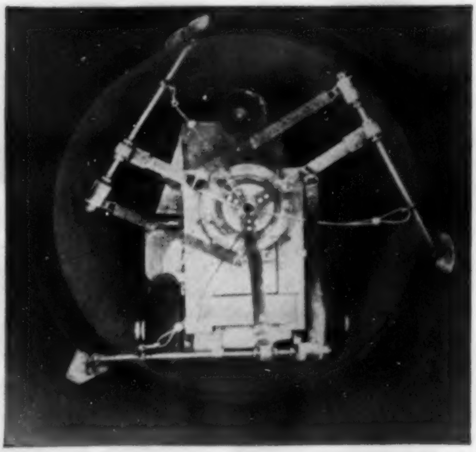

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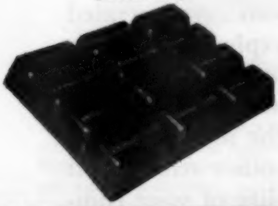

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The same dependable compound in solid form—packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX (REELS)

FIBREX

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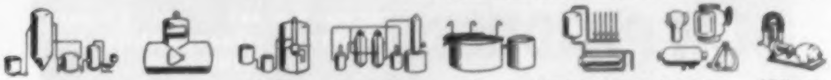

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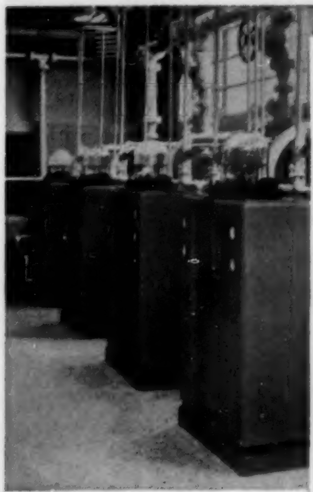

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January [illegible], [illegible]

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Clyde R. Harvill
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Superintendent
San Jacinto Water System

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 47 • MAY 1955 • NO. 5

Missouri River Basin Development

Dale L. Maffitt

A revision of a paper presented on Apr. 23, 1954, at the Montana Section Meeting, Bozeman, Mont., by Dale L. Maffitt, Gen. Mgr., Water Works, Des Moines, Iowa.

A GREAT deal has been written on the subject of development and utilization of land and water resources in the United States. The determination of the best long-range plan for the management of the great river basin projects is one of the major internal problems of the nation. Proponents of various plans have attempted to influence public opinion. Various commissions have been delegated the task of recommending a solution to the problem.

The Hoover Commission in 1949 and the President's Water Resources Policy Commission in 1950 were assigned to study the problem. In 1947 a nonpolitical group—the Engineers Joint Council—undertook an investigation of the development of the water resources of the country. The group's purpose was to make recommendations for legislation and administrative organization.

The present development program in the Missouri Basin dates back about ten years. In 1944, under threat of a Missouri Valley Authority proposal, the US Army Corps of Engineers and the Bureau of Reclamation combined their two plans for flood control, irrigation, and power development in the area. Prior to this time, the upper basin was allied with the Bureau of Reclamation, which focused first on irrigation and later on power development and flood control. The lower basin was identified with the Army engineers, which was first concerned with navigation and later expanded into flood control and hydroelectric power.

Basin Topography

The Missouri River Basin is a vast region, more than 1,300 miles long and 700 miles wide. The river, over 2,400 miles long, has its origin at Three

Forks, Mont., where three mountain streams unite. It flows north through the mountains and east across the great plains into North Dakota, then south and southeast until it joins the Mississippi, 17 miles north of St. Louis.

The river has an average slope of slightly less than 1 ft per mile downstream from the Montana-North Dakota line. Below Sioux City, Iowa, it winds along a valley 1½–17 miles wide, flanked on both sides by bluffs. There are 30 tributaries varying in length from 100 to 1,000 miles, draining areas varying in size from 2,000 sq miles to 90,000 sq miles, as well as countless minor branches.

The watershed of the Missouri River and its tributaries extends over one-sixth of the land area of continental United States, and includes all or part of ten states, as well as 9,700 sq miles of Canada. The watershed covers 529,300 sq miles, extending from St. Louis in the southeast, to Glacier National Park, Mont., in the northwest, and from Denver, in the southwest, to Bismarck, N.D., in the northeast. History shows that this area has often been subjected to intermittent periods of drought and disastrous floods. Part of it has an abundance of rainfall and part is semiarid country. Normally the problem of the upper basin is lack of water, so that irrigation is important. In the lower basin, water is more plentiful, and navigation and power interests become evident.

To demonstrate the uncertainty of weather, in 1953 Missouri was a drought area and was forced to seek assistance to secure hay for livestock. Two years earlier, in 1951, Missouri and Kansas had been ravaged by floods, which caused millions of dollars of damage. Early in 1952, late snows on the northern plains and a sudden thaw had again brought a severe flood in the usually arid middle and upper reaches of the Missouri river.

Federal Projects

Uncertainty of water resulted in the introduction of irrigation practices on the western tributaries by 1860. The early individual projects were small, but as they expanded, cooperative organizations were formed. In 1903 the Bureau of Reclamation was given authorization for irrigation projects on the Milk River in Montana and the North Platte River in Wyoming and Nebraska. These were the first federal projects for providing water to lands in the Missouri Basin.

The Corps of Engineers has been responsible for river and harbor work since 1824, its interests for a long time being navigation and flood control. It was not until 1929 that comprehensive studies of the principal river basins in the Missouri River watershed were made by this agency. In 1933 the Corps was authorized to construct the Fort Peck dam and reservoir in Montana as a navigation aid and in 1936 Congress, recognizing that destructive floods are a menace to national welfare, authorized its construction of control works in the basin, provided that the benefits seemed to justify the cost. About this time, the Bureau of Reclamation developed a coordinated plan for full use of the Missouri waters to assure irrigation in the semiarid states of the upper basin and flood control and navigation in the lower basin, as well as power and other benefits.

In the early 1940's it was becoming apparent that there was an overlapping of interests among the various agencies. The states in the basin volun-

tarily formed the Missouri River States Committee to act as a coordinating body. This group is made up of the governors of the ten states in the basin, together with appointed representatives of the governors. The committee joined with the federal agencies in working out a comprehensive scheme, commonly known as the Pick-Sloan Plan, authorized by Congress in the Flood Control Act of 1944, and has continued an active interest in the huge development program.

The Flood Control Act of 1944 recognized the rights of the states in determining the development of watersheds within their borders, as well as their rights in water utilization and control. The program which grew out of the federal authorization proposed construction of multipurpose reservoirs, irrigation of millions of acres of land, opening of navigation, building of hydroelectric plants, and control of floods, in addition to other related benefits, such as recreational facilities and health improvement.

Costs, as presently envisioned, are estimated at $11,244,265,000. It is understandable that estimates have increased each year as construction costs have continued to rise, even though the program may be proceeding, in general, according to the original plan, which called for 137 dams to be completed in the next 50–75 years. The project provides for construction by the Corps of Engineers of five reservoirs on the Missouri River in addition to the Montana Fort Peck Dam, authorized in the 1930's and now completed. The Garrison Dam in North Dakota and Fort Randall Dam in South Dakota are rapidly reaching the point where they will be able to function effectively. Garrison Dam started impounding water in 1953, and is expected to begin power generation in 1955. In a ceremony on Mar. 15, 1954, the first of the eight generators at Fort Randall Dam was put into operation, and power production is to be increased progressively as new units are completed. Power and navigation demands are increasing as facilities become available.

Uncertainties of weather again present new problems. The first 1955 water supply forecast of the U. S. Dept. of Commerce, made in January, indicates there may be a water and power shortage on the Missouri River this summer. Winter snow, which, in large measure, supplies the summer's water, has rarely been lighter in the basin area. Snow and water piled up behind Fort Peck Dam was only 60 per cent of normal. Over the Yellowstone Basin. September–December precipitation was 55 per cent of what it should be (*1*).

Construction of Oahe Dam in South Dakota is moving along slowly. The two other main river dams—Big Bend (primarily a power dam), in central South Dakota, and Gavins Point, on the South Dakota–Nebraska border—are in the advanced planning stage. These installations on the main stem will give flood protection, as well as irrigation and power benefits. At Fort Peck Dam, power installations will provide 165,000 kw; Garrison will provide 400,000 kw; Fort Randall will provide 320,000 kw; Gavins Point will provide 100,000 kw; and Oahe will provide 425,000 kw. Reservoirs which are primarily for flood control or navigation are being built on tributaries of the Missouri River by the Corps of Engineers. Reservoirs designed primarily for irrigation pur-

poses are being constructed by the Bureau of Reclamation.

Basin Committee

In its authorization of the Flood Control Act of 1944, Congress presumed that the agencies of the federal government designated to carry out the plan would voluntarily work together. To further this end, the Missouri Basin Inter-Agency Committee was established in April 1945. The ten basin states are represented on this committee by their governors; federal members represent the Dept. of the Interior, Corps of Engineers, Dept. of Agriculture, Federal Power Commission, Dept. of Commerce, and the Public Health Service. The committee is not set up by law and exercises no administrative controls. It relies for its effectiveness on the determination of its member agencies, both federal and state, to work together on a voluntary basis toward a common goal. Neither the Inter-Agency Committee nor the Missouri River States Committee has any legal status. The two committees, however, have made a studied effort to keep the public informed of the many details of the program, the progress being made, and the problems of coordination continually arising. It has been pointed out that the first steps and the final authority for coordination of the basin program rest with the Congress and the state Legislatures. Administrative coordination can proceed only within the limits of authority established by law and the appropriations that permit each phase to proceed in proper sequence.

The Missouri River States Committee has been an important instrument of the basin in appearing before congressional committees to promote the general interest of the basin states and in securing the appropriation of funds for projects under construction or contemplated. Another function has been to acquaint the people of the several states with the possibilities and purpose of this great development program. It could be said that this committee acts as a connecting link between the people of the area and the Inter-Agency Committee, the latter being more directly associated with the construction and operation of the development program.

As early as 1949 it was recognized by those in close contact with the basin program that the facilities were rapidly getting into the operational stage, and that it would be desirable to have an overall body to direct the operation of the completed projects. The members of the two committees were agreed that the public should be made to realize the problems involved in the various proposals for the Missouri Basin development and management. It was the committee's feeling that citizens in the basin area would not favor a Missouri Valley Authority if they were fully informed about the dangers involved, but would prefer a plan of operation which would preserve democratic control in the hands of the people most vitally concerned.

Basin Compact and Commission

It was felt that these two committees had been successful in coordinating the planning and construction phases of this great multipurpose project. It did appear that some organization based upon the law of the land should have jurisdiction over all phases of the development in the future, particularly as additional units are completed and put into operation. For that reason, in December 1949, the Missouri River States Committee requested the Coun-

cil of State Governments to undertake a study of the problem. A proposed compact, under which the Missouri Basin construction program could be completed and through which, by law, there could be set up a joint agency of the states and the federal government to supervise and regulate the functions, as far as their respective interests were concerned, was prepared by the Council of State Governments and presented to the Missouri River States Committee. After study, a revised draft was prepared in printed form in January 1953. The proposed compact was again reviewed and certain changes made in wording at a meeting of the committee in December 1953.

The idea is not new, but the proposed Missouri Basin Compact is unlike previous agreements in that the United States will become a full party. The ordinary compact, although raising a federal question for jurisdictional purposes, is only state law, while this Missouri River compact will be a federal statute as well. Representatives from the various states of the basin and from the federal government will constitute a Missouri Basin Commission, whose function will be to administer the compact, the purpose of which (given in Article 1) will be:

> . . . to facilitate the expeditious agricultural, industrial, and recreational development of the Missouri River Basin through a unified intergovernmental program for the management, conservation, utilization, and development of the land and water resources of that Basin.

The explanatory statement preceding the proposed compact proper says:

> It appears that effective development of the Basin's water and land resources requires a new type of regional organization, one which is tailored to fit the Basin's special needs. Such a regional organization for the Missouri Basin, it is believed, should: [1] assure a high degree of Basin-wide coordination; [2] provide for effective participation both by the states of the region and by the national government in the formulation of basic, broad policy; and [3] utilize established governmental agencies in the construction of facilities and in the operation of programs.
>
> The suggested Missouri Basin Compact is an interstate compact among the signatory states, and between the states and the national government. . . .
>
> The Commission is not empowered by the compact to engage in any regulatory or operational activities. It is prohibited from drawing specific construction plans for particular projects and from engaging in any construction work. These functions are to be carried on by other agencies of the participating governments.
>
> The Commission is charged with [1] formulating overall plans for the development of the Basin's water and land resources; [2] reviewing proposed construction and operational plans to determine whether such proposals are consistent with the overall plans for the Basin's development which the Commission has approved; and [3] reviewing actual operations to determine whether approved plans are being carried out properly. . . .
>
> The compact specifically states that none of its provisions should be construed to affect state or federal laws as they pertain to water rights, nor to restrict the jurisdiction of existing agencies of any member government.

Basically, the Commission's powers are recommendatory only. But the official character of the body as an organic agency of the Basin's states and of the national government will endow its recommendations with considerable weight; such recommendations will receive careful consideration by legislative and executive officials of the member governments.

Congressional Legislation

The Missouri River States Committee, at its meeting in June 1954, agreed that before the states could proceed to negotiate such a compact between the ten states and the federal government, it would be necessary to have the authorization of Congress. The committee had prepared a bill to authorize the basin states to proceed with the adoption of the Missouri River Basin Compact. The proposed legislation had been introduced as Senate Bill No. 2821.

A resolution was adopted by the Missouri River States Committee at the June 1954 meeting to the effect that representatives of the committee should request the passage of Senate Bill No. 2821, because the proposed legislation conformed to the type of compact authorization the Missouri River states favored. Several other bills had been introduced into Congress advocating other methods of management of the basin projects. Senate Bill No. 2821 ultimately passed the Senate in a substantially revised form, but did not pass the House.

The matter of compact authorization was reviewed at a meeting of the Missouri River States Committee in December 1954. Opinion was divided on the method of authorization. Several members favored the principles contained in the compact, but proposed that there should be an act of Congress which would be more inclusive and embody most of the principles of the compact in the legislation. It was agreed that another attempt should be made to get an authorization of the compact, by enabling legislation, during the 1955 session of Congress. If this should not be successful, the committee made up of the new governors taking office in 1955 should decide what further steps should be taken.

The proposed bill was introduced in the House of Representatives on Jan. 5, 1955, as H. R. 109. The bill was referred to the Committee on Interior and Insular Affairs. The text of H.R. 109 follows:

A BILL To grant the consent of Congress to the States of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming to negotiate and enter into a compact relating to the conservation, development, and utilization of water, land, and other related resources of the Missouri Basin and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled That the consent of Congress is hereby given to the States of Colorado, Kansas, Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, or any six or more of them, to negotiate and enter into a compact with each other and with the United States of America, providing for means for the attainment of the conservation and development of the land and water resources of the Missouri Basin, through a basin-wide, comprehensive program for the unified planning, development, and operation of those resources, integrating the resource development programs and operations of agencies of the United States and of the States, and for securing effective coordination and cooperation between the States and between the United States and the States: *Provided,* That existing compacts between the States and decrees of the United States Supreme Court relating to any of the waters of the Missouri River or its tributaries shall be fully recognized: *Provided further,* That any compact negotiated pursuant to this Act shall provide that the use for navigation of waters arising in States lying wholly or partly west of the ninety-eighth meridian shall be only such use

as does not conflict with any beneficial consumptive use, present or future, in States lying wholly or partly west of the ninety-eighth meridian, of such waters for domestic, municipal, stock water, irrigation, mining, or industrial purposes.

Sec. 2. The President is authorized to appoint a commissioner to represent the United States in such negotiations, who shall make a report to the President and to Congress of the proceedings and of any compact entered into.

Sec. 3. Any such compact shall not be binding or obligatory upon any of the parties thereto unless and until the same shall have been ratified by the legislatures of each of the States whose assent is contemplated by the terms of the compact, and by Congress.

Sec. 4. There is hereby authorized to be appropriated such sums as may be necessary or appropriate for administering the provisions of this Act.

Conclusions

If this proposed legislation is enacted, the next step to be taken by the Missouri Basin states will be the negotiation of a compact. If it is not enacted, then some other plan of operation and management must be considered. In the meantime, the members of the Missouri River States Committee and the Missouri Basin Inter-Agency Committee feel that they can continue to solve problems, as they arise, in the same spirit of cooperation which has brought results in the past, as development of the basin has gone forward. They also feel that citizens in the Missouri Basin area would not favor a Missouri Valley Authority (or any other agency of the federal government) at the administrative head of the operation and management of the projects in the area.

The members of these committees believe that they should move slowly in setting up the plan of management, to the end that democratic control should remain in the hands of the most vitally concerned people—those who live in the Missouri River Basin.

Reference

1. *Business Week*, p. 56 (Jan. 29, 1955).

Central Dispatching for Distribution Systems

R. M. Collie

A paper presented on Oct. 19, 1954, at the Southwest Section Meeting, El Paso, Tex., by R. M. Collie, Partner, Freese, Nichols & Turner, Cons. Engrs., Houston, Tex.

APPLICATION of central-dispatching methods to the operation of water distribution systems is receiving increasing interest. Dispatching is the prompt and orderly control and allocation of a commodity or service. When performed in a central location, the function is known as central dispatching, and the person exercising control is called the dispatcher. Everyone familiar with railroad or public-transit dispatch operations is well aware that in these service fields firm central control is a necessity for any degree of intelligent operation. Dispatching in gas, electric, and pipeline operations also has proved to be essential, if the utilities are to perform efficiently.

In the water works field, central dispatching has not yet received the attention, nor has the extent of application experienced in the utilities previously mentioned. This is not to say that the methods of central dispatching have been resisted, but rather that the advantages have perhaps not been fully realized. Basic central-dispatching operations require the collection of concurrent information on pumping station flows and pressures, distribution system pressures, storage in reservoirs and tanks, and other vital information. These data must be received simultaneously and immediately in order to form the basis for constant direction of the system operations by a person in central authority. A continuous flow of information enables him to know whether or not orders are being executed and also permits a prompt spotting of abnormal conditions. This information and control is necessary for satisfactory and economical operation of a complex water system.

Need for Dispatching

Dispatching is, of course, applied in its elementary form even to the smaller water systems, where there is one source of supply, one pumping station, and, perhaps, one overhead storage tank serving a community. The operator knows from experience approximately what the water requirements will be and the desirable output pressure, depending upon the time of day and the season of the year. He knows the water level in the overhead tank by observing some type of gage, and when the fire alarm is heard, he is prepared to furnish the additional water. The operator is personally acquainted with the distribution system and sources of water supply, and can detect any serious trouble soon after it develops. Thus, in a small system the functions of dispatching are intimately associated with the function of plant operation, and both of these functions

are carried on in one location by a single individual.

A more complicated situation arises when a second pumping station supplying a distribution system is considered. The two stations may have independent sources of water supply, or one station may be a satellite. It is necessary that the operations of the two stations be coordinated to effect balanced system performance. Possibly, the operators in both stations are thoroughly familiar with the distribution system being supplied and the local variations to be expected, and can operate largely independently of each other. Nevertheless, it is necessary that some form of control be in operation between the two stations so that the total load can be apportioned between them and so that emergency conditions can be accommodated. This control may be handled quite informally over the telephone, but it is present, nevertheless.

As the system becomes larger and larger, and as more pumping stations are added, it becomes so complicated that the operators at any one station can be sure of little more than their own station pumpage and pressure. They have no basis upon which to judge the effect of their operations on surrounding stations, or on the distribution network. If major trouble develops, operators at the various pump stations may not know about it, or, if they do, are not in a position to determine the proper corrective measures to be taken at each station. The coordination required under these circumstances is the function of central dispatching. The dispatcher instructs each station on how to correct pumping and pressure, checks for compliance, and observes pressures at critical locations throughout the distribution network. He can promptly detect any abnormal condition and, depending upon basic instructions, can either take corrective action directly or report the situation to others responsible for such steps.

Houston Distribution System

Houston provides an excellent example of the development of a large and complex water distribution system where there is a need for a central-dispatching program. The system serves an area of 155 sq miles and, with eight major pumping stations and thirteen small stations, distributes water through 1,475 miles of water lines in sizes from 2-in. to 36-in. Forty per cent of the water-line mileage consists of 2-in. pipe, and there are 190, 380, and 135 miles of 6-in., 8-in., and 12-in. mains, respectively. The pumping capacities of the eight major stations vary from 13 mgd to 60 mgd, with a total capacity of 265 mgd.

As may be expected, the Houston system has inherent peculiarities which probably are not found in any other installation of comparable size. Until the recent completion of the San Jacinto River supply system, all of the water for Houston was pumped from wells. As the city grew, additional well fields were developed and pumping stations built to serve the surrounding areas. Thus, Houston has today what amounts to seven separate large systems, each complete with wells and pump station, plus the new surface supply. These various systems are, of course, loosely connected together, but there is an absence of large arterial mains usually found in a distribution system the size of Houston's. This accounts for the small line sizes described.

The development of the San Jacinto River system introduces the problem

of a major new supply, potentially larger by far than the aggregate capacity of the seven ground water systems. Located on the margin of the city, the supply requires an entirely new system of arterial mains to feed the water into the established system. The seven ground water systems are referred to as the: Heights plant, Northeast plant, East End plant, Scott Street plant, South End plant, Southwest plant, and Central plant. In addition, thirteen small, fringe systems are supplied by plants consisting of one or two deep-well pumps, a ground storage tank, and a booster pump or an elevated tank. The capacities of these plants vary from 2,000 gpd to 1.2 mgd.

The Channel pump station is the eighth major installation. It supplies treated surface water from the recently completed purification plant. At the present time, the water is pumped through a 36-in. line into the Northeast area, taking over in part areas previously served by the Northeast, East End, and Central plants. At a future date, two large mains will be extended from the Channel pump station and will take over areas presently supplied by the East End, Scott Street, and South End plants. These three installations will be retired from service as their wells wear out.

In addition, there is the industrial system supplying raw San Jacinto River water to industry along the ship channel. The installation has a capacity of 75 mgd. The industrial-water system is, of course, completely independent of the potable-water system, but it does secure its supply from the same canal, 14 miles long, that supplies water to the treatment plant. The industrial distribution system must be independently controlled in its distribution function, but the source of water to the industrial pump station and to the purification plant must be coordinated and dispatched, because it comes down the same canal from the dam on the San Jacinto River. Dispatching in the raw-water system must be based on an 8-hour anticipation of water requirements. This period is the time necessary for an increase or decrease of water flow from the pump station at the San Jacinto River to be felt at the purification plant and industrial pump station.

Central-Dispatching Need

Operating a water system as large and complex as Houston's is a demanding job. Without a well organized central-dispatching system, it can be (and has been) an extremely difficult one. The rapid growth of Houston over past years has kept the city hard pressed for funds to provide required utility service, without any refinements. Nevertheless, the utilities department has managed to operate the water system by making telephone calls to the various plants to secure operating data and to issue instructions. This is a slow and laborious and not very accurate process. There is no satisfactory way to determine if instructions are being carried out. Early in 1953, the city council authorized a central-dispatching system, and studies were promptly undertaken. Work is going forward, but as yet the system is not complete.

The need for a central-dispatching system was strikingly demonstrated in October 1954. The Channel pump station went into service in late summer 1954, and the 20–23 mgd that was being fed into the northeast areas had

very little effect upon the East End, Central, and Northeast plants. There were some complaints about tastes caused by reversal of flow in the mains, but this situation soon cleared up. Eventually, however, the seasonal reduction in water consumption, together with the continued 20–23 mgd output from the channel pump station (required for economical operation), upset the functioning of the water system in the eastern half of the city. Pressure rose as much as 20–25 psi above normal in some areas, and it was necessary at one time to shut down the East End plant and to reduce greatly the pumpage at the Northeast and Central plants. There were many complaints about high pressure, low pressure, and tastes caused by flow reversals. The trouble was gradually worked out in a few days, but if the central-dispatching system had been in operation at that time, the situation would not have been allowed to develop. A few orders over the radio network or the telephone by the central dispatcher would have averted the difficulty.

Selecting Equipment

In selecting a telemetering and central-dispatching setup for the city's water system, basic considerations were given to the information to be collected and the means of transmitting the data to the central-dispatch board. It was decided to receive flow and pressure information from the eight larger pump stations, and pressure information from five additional strategic points on larger water mains, remote from the pumping stations. It was not necessary to cover the smaller stations, as they could be operated unattended and on a prearranged schedule. The main instrument panel at the central-dispatching board was arranged to mount recording-indicating-totalizing instruments to receive the flow quantity data from each of the eight stations. One instrument records and indicates the integrated total flow for all stations. In addition, there are thirteen instruments recording and indicating pressure at the eight stations and the five additional pressure points. The data received from the central-intelligence board indicates the pressure existing at the various points of the whole system, and by comparison of individual station flow with known station capacity, the dispatcher can decide which stations should increase or decrease output. Also included are flow and pressure recorder-indicators for the industrial pump station which handles untreated water.

Cost studies quickly revealed that leased telephone circuits provided the least expensive means for transmitting information to the central-dispatch board. Construction costs of private circuits, much of which would have had to be underground, were prohibitive. A radio network was also considered, but this idea was discarded because of high costs. Only a single telephone circuit from each source of information is required for transmission of multiple signals, because several separate signals can be transmitted by utilizing sequence transmission equipment for time-duration pulse signals, or by employing filters for continuously transmitted frequency modulation signals.

Equipment Location

As soon as the listing of the instruments to be installed on the main panel was completed and the physical size of the panel determined, it was necessary to select a suitable location. The ideal instrument board would have a

solid front with walk-in space behind, needing a room about 30 ft long. It was required, too, that the room be separate from other facilities and offices and that it contain only the panel and space for the dispatcher's desk. It had previously been determined, on the basis of monthly telephone company charges for leased lines, that the use of either the city hall or the central pumping station would obtain minimum monthly cost. Because of lack of suitable space in the city hall, as well as the fact that the central pumping station is one of the city's maintenance headquarters, it was decided to place the main panel at the station.

An old plant, it is still operated on steam. The building is large and only partly occupied by pumping equipment. The structure has a very high ceiling and a below-grade pump room floor. Space was available in the building, but a complete office would have had to be built, supported on columns above the basement pump room floor. As a roof, a floor, and three walls would have had to be constructed, as though the office were an outside building, it was decided to use an existing walled space which had been serving as a chlorination room. The disinfection equipment was removed and installed in an extension of the office. The vacated space was about 9 ft by 16 ft. The room was rewired and provided with fluorescent lighting fixtures. A window model air-conditioning unit was installed, the front flush with the instrument board, and the rear extending through the wall behind the panel.

Equipment Design

The limited space available for the main instrument panel dictated the type and arrangement of the board. First, it was necessary to make the panel U-shaped. Second, it was required to make the panel shallow in depth and to mount the instruments on doors. Third, the panel had to be built in 38-in. sections, which could be moved into the office through the door and then assembled. The arrangement resulted in having the dispatcher's desk just inside the door, with four 38-in. panel sections in front of the desk, one section on the left, and two sections on the right. Specifications for the instrument panel required hidden removable pin-type hinges, with two full-length doors for each panel section. Recording-indicating instruments were mounted on the doors which are normally closed. Chrome-plated latches are practically flush with the panel front, and engage a floating nut to keep the door locked at all times. Extra-flexible, switchboard cable to the instruments allows for the swing of the door when it is necessary to gain access to summator and signal sequence devices mounted inside the board. The resulting panel front is continuous, with only vertical division lines between door and panel sections.

The writing of specifications for the instruments was comparatively simple, inasmuch as standard instruments offered by several manufacturers were acceptable. The specifications were functional, except in naming the type of mountings, instrument cases, chart drives, and other details.

A good deal of ground work was necessary in order to check and tabulate the existing primary flow-sensing devices, so that the equipment offered by the various bidders would function with existing apparatus. The capacity of each station had to be checked, and the range of each instrument specified. In order to describe completely the in-

stallation at each station, suitable locations for all instruments had to be selected and sketches prepared, designating the location of each instrument to be furnished. The specifications also had to outline in detail the exact items of work to be performed. At the pressure check points, city forces were to make the main-line taps, and to extend pressure tubing up to the instrument location. Much of the labor in developing the specifications consisted of field surveys and careful notations of existing installations and narrative descriptions of required work.

Appreciable economies in instrument costs were effected by keeping the various requirements to a minimum. Because all the plants had pressure and flow indicators and recorders, the transmitters were all specified as nonindicating. Even the pressure check transmitters at the five pressure check points were nonindicating, and it was found economical to have standard pressure gages mounted on the pressure line next to the transmitters.

The most difficult feature of the whole system was the necessity of taking signals from primary devices utilizing propeller-type meters. Some of the pump stations had as many as three of these flow meters. At least one station had both a propeller meter and a venturi type of primary device. The problem was to convert the rotating motion of the propeller meter to an electrical signal, which could be summed with signals from other primary devices and transmitted through the sequence transmission equipment. This task limited the number of manufacturers who could bid on the instruments, because many companies could not furnish the necessary adapters.

The signals were to be transmitted over leased telephone wires, so the type of signal to be used for the telemetering had to be acceptable to the telephone company. At first it was thought desirable to have a time-duration 15-sec cycle signal, commonly used for telemetering. A special transmitter would not have been required for the telemetering of the four functions from the water purification plant, as 15-sec cycle equipment is used throughout the installation. The first set of specifications required such a signal; it was thought that several manufacturers would be able to supply the instruments. This proved to be wrong, however, although one manufacturer, normally using a frequency-modulated signal, could furnish the intraplant transmitting equipment which used the 15-sec cycle signal at the treatment installation. In order to develop competition in bidding, it was necessary to issue new specifications permitting the use of frequency-modulation and 15-sec cycle signals. Keen competition developed, and the manufacturer with the time-duration 15-sec cycle signal was low bidder with a very reasonable price.

Equipment Bids at Houston

Houston's experience in taking bids for the telemetering facilities should be of interest. Preliminary estimates indicated that a complete telemetering facility could be purchased and installed for approximately \$4,000 per pump station, and about \$1,000 per pressure check point. The usual procedure of taking bids for a complete job was followed. It developed that only a few local electrical contractors bid on the work. Apparently they had received quotations at the last minute

from one manufacturer, and had added about 75–80 per cent of the instrument cost. This placed the total bid in the neighborhood of $7,500 for each pump station and $2,000 for each pressure check point. Actually, the bids were more than 50 per cent over the engineer's estimate. All the offers were thrown out, and new bids were taken for instruments only. Two manufacturers bid on the instruments, and the prices were within the original estimate. It appears that the city will be able to have the complete facilities installed at the costs initially anticipated.

Houston's plan is to take bids on the main instrument board as "factory wired." This term means that the manufacturer will fabricate the panel, install and wire all the instruments, and then deliver and install the board at the central-dispatching station. By this method, all the wiring on the main panel is installed in the manufacturer's shop at considerable saving over a field-wiring job. The saving is appreciable, because the bulk of the wiring for the whole system is in the main board. The panels are made in 38-in. sections and the manufacturer arranges the wiring so that it is easily disconnected and reconnected during the final assembly in the central-dispatching station.

To complete the installation of the system, bids are to be taken for setting in place the various instruments at the pumping stations and pressure points. With all the drawings of instruments and wiring diagrams available, it has been possible to describe in detail the work of installation. As a result, it has been expected that very reasonable bids are to be received for the work and that the final total cost will be within the estimates and appropriations.

The experiences of Houston in construction of a telemetering system indicate that it is quite economical to purchase instruments and panel boards separately and have installation of the components performed by a contractor or city forces. A telemetering system for a city the size of Houston is so small that large engineering contractors who have experience with instruments will seldom undertake the job. Further, local commercial electrical contractors are often either unable or unwilling to undertake this work.

Remote Control in Water Systems

E. Wylie Head

A paper presented on Nov. 8, 1954, at the Florida Section Meeting, St. Petersburg, Fla., by E. Wylie Head, Sales Mgr., Control Corp., Minneapolis, Minn.

DURING the past several years the terms "supervisory control" and "telemetering" have been heard more and more frequently in the water works field. Supervisory control is the control of equipment at a distance and the supervision, by means of signals, of the status of this equipment.

Supervisory control and telemetering were first used on a limited scale by the electric utility industry in the late 1920's. Since World War II this industry has made extensive use of such equipment, and most sizable utility systems have some in service. At present there are several water systems using supervisory control and telemetering. Operations usually performed by supervisory control include the starting and stopping of pumps and the opening and closing of valves. Operations performed by telemetering include remote meter readings of tank or reservoir levels, pressure, and flow. Both supervisory control and telemetering can be used to control various pump programing schedules.

Reasons for Use

There are three principal reasons why there is such an increasing interest in these two items by water works engineers. The first, and perhaps most important, cause is the increasing cost of labor at pumping stations and similar installations. The labor costs of manning a station for 1–2 years will usually pay for sufficient supervisory control and telemetering to eliminate manual operation of such a plant.

A second reason for the trend toward this type of equipment is improvement in service. Where two or more plants have to be coordinated for proper operation of the system, this can usually be done better by centralized control under one operator. With such a system the central operator has complete facilities to perform any necessary operations at remote locations and has adequate information on what every unit in each remote station is doing.

A third reason for the growing use of this type of equipment is labor unreliability. During periods of labor unrest, it may be unwise to depend upon local operators at the various plants comprising a system. Operators employed at a centralized dispatching location, however, are generally not affected by labor disturbances.

There are several factors to be considered in designing supervisory control, the most important one being reliability. It goes without saying that the components used in the equipment should provide a reasonable period of trouble-free operation. Aside from this, the most important consideration

is the protection provided by the equipment against operation by signals that do not originate in supervisory control mechanisms. Examples of such signals would be those caused by cross talk, switching surges, and lightning. The equipment can reasonably be expected to encounter some types of spurious signals during its life. The improper operation caused by such signals would be at least annoying and could be disastrous in basic pumping stations.

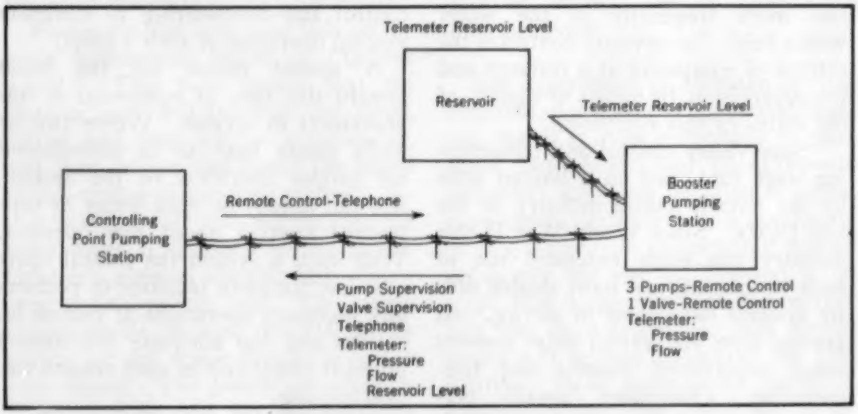

Fig. 1. Installation at Lake Forest, Ill.

A single pair of leased telephone wires serves for telemetering, controlling, and telephoning.

Types of Supervisory Control

During the last 20 years, two primary types of supervisory control equipment have been evolved by three different manufacturers. The older of these types is known as "impulse" supervisory control. In this system, all operations, both remote control and supervision, have signals in the form of short electrical pulses, somewhat similar to those obtained in telephone dialing. If it is desired to operate remote equipment, a button is pushed which transmits a certain combination of these pulses to the remote location. The manufacturers of this type of equipment recognize that a short pulse of electrical energy can be easily duplicated from external sources, and it is required that the remote-location equipment transmit an equivalent grouping of pulses back to the originating or controlling station. If the combination of pulses coming back agrees with the one going out, the operator is allowed to transmit and operate a signal composed of a short grouping of impulses. This system, known as a "checkback," is a necessary part of any impulse system to provide minimum protection against spurious signals.

In place of control impulses easily duplicated from other sources, a system composed of a sequence or combination of audio-frequency tones has been evolved. In place of using the

one checkback feature of the impulse system, automatic checking of the signal is provided at the remote location as it is received, with six different checks necessary before an operation is allowed to take place. In this "audio-sequence" type of supervisory control, all remote control signals are composed of a minimum of three (usually four) audio frequencies transmitted one at a time in a definite sequence. The resulting operation depends only upon the sequence or order in which the tones are transmitted. Audio-frequency tones usually used for remote control are 210, 310, 350, 390, and 430 cycles. As this combination of audio-frequency tones is received at the remote location, the six checks previously mentioned are imposed. The first check measures the number of audio frequencies and requires that this number be correct before an operation is allowed to take place. In place of a random electrical impulse, the frequencies must be correct within 3–4 cycles or no operation is allowed to take place. The frequencies must arrive in a definite, restrictive sequence that corresponds to preset combinations. No operation is allowed to take place if two frequencies come in simultaneously, and the interval between frequencies must not exceed a predetermined limit. In addition, no frequency can immediately follow itself.

In considering the various possibilities for spurious signals that might be encountered during the life of the equipment, it can be readily seen that the six checks effectively rule out any chance of incorrect operation. The audio-sequence system allows generally faster operation than can be obtained with the impulse system. Wide use throughout the United States, Canada, and Mexico attests to audio sequence reliability.

Forms of Equipment

Supervisory control equipment can be in many patterns and operate over several different types of channels. The controlling- or dispatching-station equipment can take the form of a switchgear type of cubicle, a wall-mounted cabinet, a desk, a benchboard, a system diagram on a large panel, or various other aspects that might be most suited to a particular application. In general, the equipment at the controlled end is housed in cabinets or cubicles of various sizes and styles. The panel at the controlling location is usually composed of a group of bakelite rectangles known as escutcheons. An escutcheon provided for each piece of remote equipment being controlled or supervised comprises three lamps to show the status of the equipment, an operation selector switch, and an operating-lever key. In some cases this lever key takes the form of a push button. If telemetering is associated with the equipment, the appropriate indicating or recording meters are placed above or below the control panel.

Telemetering, if used, takes one of two forms. The telemetered measurement value can be brought in continuously and usually will operate a recording instrument. Where the readings may not be required continuously, the supervisory control equipment will select any desired measurement and bring it in as required. Almost any number of such selections can be made, one reading at a time being brought in to appear usually on an indicator. The channel connecting the central controlling location with the one or more remote stations can take several forms. Often this is a pair of

telephone wires, either leased or owned by the user. The wires can be one of several pairs in a telephone cable or can be a pair of open telephone wires. Microwave radio is now being used more often as a connecting channel. It is generally possible to control almost any number of operations in one or more plants over one pair of wires or channel. In addition, it is possible to bring back a large number of lamp indications from remote locations, as well as a large number of telemeter readings, over the same pair used for remote control of the station or stations. In addition to supervisory control and telemetering signals on a pair of wires, it is fairly common to have this same pair also used for telephone.

The possibilities involved in the use of supervisory control and telemetering are many and varied. In general, standard, proved circuits and components are used to build equipment to the specific requirements of each user.

Four Specific Installations

Four applications of supervisory control and telemetering to the control of water systems are described in the remaining part of this paper. The first of these is used by the city of Lake Forest, Ill., and was installed in 1951. Figure 1 is a diagram of the system. The controlling-station equipment is mounted in an older pumping station, and it is used to control three pumps and one altitude valve in a new booster pumping station over a pair of leased wires. Water to the booster pumping station is from a nearby reservoir. Water level measurements are transmitted over the same pair of wires used for control. From the booster pumping station itself are tele-

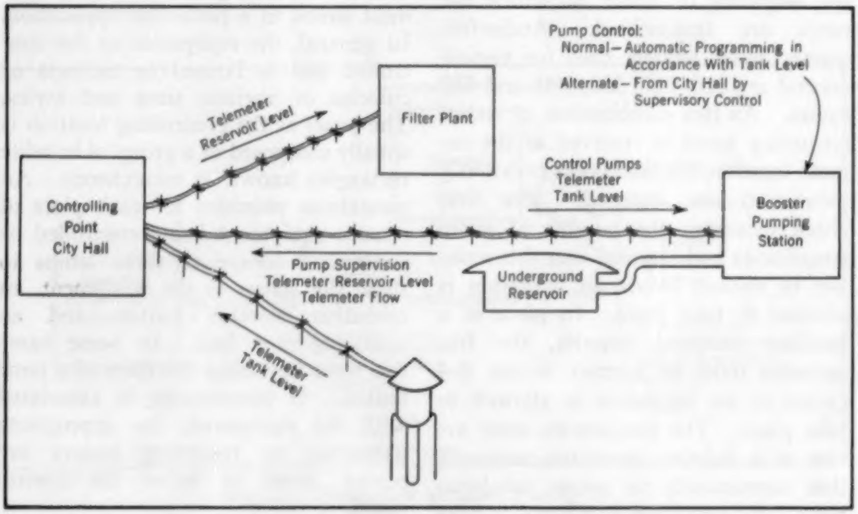

Fig. 2. Installation at Aberdeen, S.D.

An operator at city hall can tell at a glance the status of every part of the system, and can control any desired operation.

metered one pressure and one flow value. Telephone currents are also sent over the same pair of wires. The supervisory control equipment is so arranged that at a later date automatic pump programing may be incorporated.

Another installation is at Aberdeen, S.D., also set up in 1951. This involves a central controlling point located at the city hall. Water level information from an elevated tank is telemetered into the city hall and then to the booster pumping station. The operator at the city hall has a reading in front of him at all times showing the water level in the elevated tank, as well as water level in an underground reservoir, where a reading is sent over a separate pair of wires to the filter plant. The operator also has a telemetering instrument giving him the flow rate at all times from the booster pumping station. The elevated-tank water level information which is brought into the city hall and extended to the booster pumping station is used to control an automatic pump-programing unit. The appropriate pumps are operated in accordance with water level in the elevated tank. The operator sees which pumps are running at all times by means of lamps on the control panel. He has the option at any time of taking control away from the automatic programing equipment and directly operating any or all pumps by supervisory control. Figure 2 illustrates the layout of the various elements in this waterworks system.

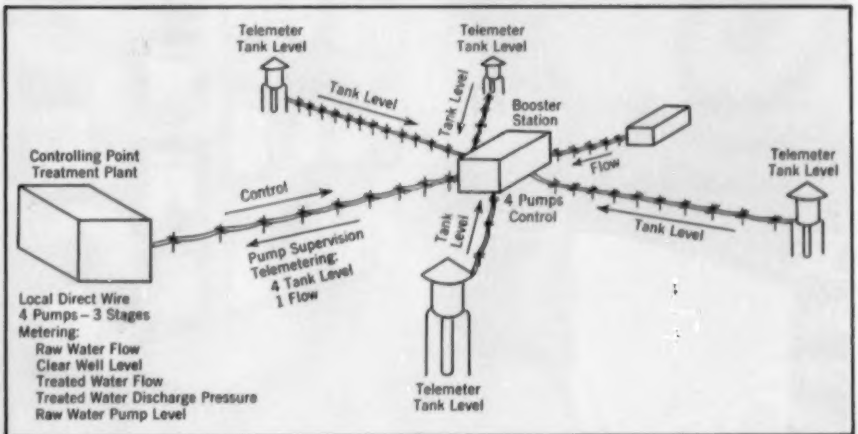

Fig. 3. Installation Near Dallas, Tex.

The centralized control of this plant results in substantial savings in manpower costs.

The third installation is used by the Dallas County Park Cities Water Control and Improvement District No. 2, and is located near Dallas, Tex. The controlling station is in a section of the treatment plant. On the operator's control and supervision desk are provided control escutcheons for three stages each of four different pumps in the treatment plant. The meter panel also shows data for the treatment plant: raw-water flow, clear-well level,

treated-water flow, treated-water discharge pressure, and raw-water pump well level.

Water level information from four different elevated tanks is telemetered to the controlling operator, as well as flow data from the meter station. The operator has direct control of four different pumps in a booster station and knows at all times which pumps are running and which are not. As in all supervisory control, any shutdown of a pump by the protective equipment will immediately notify the operator by means of an audible alarm and a change in lamps which calls attention to the actual unit that has changed its condition. Figure 3 illustrates the layout and Fig. 4 shows the operator's desk and part of the meter panel.

Fig. 4. Operator's Desk and Part of Meter Panel

This is the control room at the plant near Dallas. Any shutdown of a pump by protective equipment will result in an audible alarm and a change in lamp color.

The fourth water works system is that of Fort Lauderdale, Fla. The project there involves a telemetering of water level from five different tanks, located adjacent to the central-dispatching station, to each of two pumping plants. At each plant recording instruments provide a continuous record of the water level in the tanks. From the central-dispatching station, line pressure values are continuously telemetered. In addition

to the direct recording of the pressure at each plant, this value is telemetered to the other plant and the central-dispatching station. At one plant automatic control of pumps is achieved by telemetered water level indications. From a fourth location water level information in the tank is telemetered to one of the pumping plants and used to operate supervisory control equipment which controls pumps in a well field located elsewhere. The seven values telemetered to each of the two pumping plants are all carried over one common pair of wires. In no case is more than a single pair of wires used except for the control and supervision functions connecting the well pumps in the field to the well field supervisory control cabinet.

Conclusion

From the few applications described, it may be seen that supervisory control and telemetering can be combined and applied in a wide variety of ways. In each case the application of this equipment has resulted in important savings in man power and has contributed greatly to better and more efficient operation of each of the water works systems. The elimination of operators at a normally attended station, or the elimination of the need periodically to send operators into a station, can result in substantial savings in man power costs. Use of supervisory control and telemetering, in combination with automatic equipment where needed, can result in much more efficient operation of any water works system.

Laws of Florida Governing Water Use

Frank E. Maloney

A paper presented on Nov. 9, 1954, at the Florida Section Meeting, St. Petersburg, Fla., by Frank E. Maloney, Prof. of Law, University of Florida, Gainesville, Fla.

DURING the last 50 years, use of water from public, industrial, and irrigation supplies has increased tremendously in the United States. Not only has the per capita use grown, but the water-using population has doubled during the same period, thus further multiplying the demand (*1*). Between 1890 and 1945 water use increased from 2,050 mgd to 12,030 mgd (*2*), almost sixfold in 55 years, and growth since 1945 has been at an even faster pace.

The former chairman of the National Water Resources Committee predicted in 1952 that industrial demand for water in the United States would double in the next 10 years and that this increased demand would still represent only about 25–35 per cent of the total water consumption because the demand for other uses, such as irrigation and steam power, would correspondingly increase (*3*). An extensive growth of industrial demand in the Southeast is occurring. Two of the industries which are expanding—pulp and paper, and steel—lead all others in industrial water requirements. Further, the use of water for irrigation, although still in its infancy in this region, is showing signs of rapid and vigorous growth. A recent survey in South Carolina, now blessed (like Florida) with an abundant water supply, indicates that between 1945 and 1950 industrial use of water in that state increased 350 per cent; use by cities in the same period increased 80 per cent; and use on farms almost doubled (*4*). Farmers in South Carolina, as elsewhere, are suddenly realizing the tremendous value of irrigation in increasing farm production and reducing the risk of damage from droughts. A similar upsurge in the demand for water for irrigation in Kentucky has led to several recent studies of the laws governing use of water for that purpose in the state (*5, 6*).*

Florida Problem

Past and potential increases in irrigation and industrial demand in Florida (*7*), added to the problems created by salt water intrusion in many areas along the coasts (*8*), call for a reevaluation of Florida's water laws in the light of present and future needs. Other southeastern states are already tackling the problem—South Carolina in 1953 created a water policy committee to recommend steps to bring about full use and protection of state water resources. This committee, guided in part by a study made in

* This problem and its legal aspects are also discussed, with particular reference to North Carolina, by Beverly C. Snow, in "Eastern Water Shortage and Drought Problems—Growth of Eastern Irrigation Demands," *Jour. AWWA*, **47**:226 (Mar. 1955).—*Editor.*

1952 by the US Soil Conservation Service (*9*), has recommended legislation drastically changing South Carolina water laws. A similar study is being conducted in Mississippi and another, with proposed corrective legislation, was made in Wisconsin in 1953 (*10*).

One of the first projects of the new Bureau of Water Research, following activation in July 1955 at the University of Florida, will be a complete review of the state statutory and common law having to do with the conservation and use of surface and ground water. It may be appropriate at this time, however, to consider in broad outline the present state of Florida water law and to point out the need for more detailed study aimed at corrective legislation.

This survey does not consider the legal problems involved in pollution, although that naturally affects the amount of water available for use in Florida. Further, the survey does not deal with flood control, although impoundments for this purpose will make tremendous additional quantities of water available in certain areas of southern Florida.

Law of Watercourses

There are three different judicial views on the use of water from running streams. The oldest is the English natural-flow rule, under which an upper riparian owner may not alter the natural flow of a stream except to make use of the water for purely domestic purposes. This rule was adopted in England when the use of water for industry and irrigation was still on a very minor scale and the predominant problem was prevention of pollution. The law met the social needs of the time, but it is not adequate for today's greatly expanded economy. Rigid adherence to this antiquated doctrine aggravated the problems in South Carolina and helped bring about proposals for a comprehensive code providing for a modified system of prior appropriation (*4*). The recommendations follow closely the present Kansas code (*11*).

Under the prior-appropriation doctrine as judicially enunciated in the western and Rocky Mountain states, a riparian or other owner could appropriate the right to use as much water as he could successfully divert and beneficially employ, so long as his appropriation was prior in time to that of others; in an extreme case, his right (on a sort of first come, first served basis) might extend to exhausting the flow of the stream. This doctrine, with modifications, is now confirmed by legislation in most western states (*12*).

The third approach is through the theory of reasonable use. This modification of the natural-flow rule entitles a riparian complainant to protection only when the defendant's diversion unreasonably interferes with the complainant's use of the water. The doctrine emphasizes full use of the available water supply, and each riparian owner may make beneficial use of the water for any purpose to the extent that his use does not unreasonably interfere with the beneficial uses of others (*13*).

The exact state of the law as to supply from watercourses in Florida is not too clear. In one early case, where the primary consideration was the pollution of an "underground stream" used as a source of water supply by Tampa, the Supreme Court of Florida restated the common-law riparian rule along with the reasonable-use modification (*14*):

The right to the benefit and advantage of the water flowing past one owner's land is subject to the similar rights of all proprietors on the banks of the stream to the reasonable enjoyment of a natural bounty, and it is therefore only for an unauthorized and unreasonable use of a common benefit that any one has just cause to complain.

Because the court was not called upon to consider to what extent the doctrine of reasonable use in Florida may permit the diversion and use of surface water for such purposes as irrigation or manufacturing, the case does not establish a binding precedent on those points. In the absence of a legislative adoption of the prior-appropriation doctrine, it is probable that when the problem is squarely presented to the Florida court, it will follow in the path of most of the other southeastern states: placing the stress on the reasonable-use aspect of the common-law doctrine and permitting diversions which do not unreasonably interfere with use by other riparian owners.

The reasonable-use theory, although it permits much broader and more nearly complete utilization of the water than the older natural-flow theory, has two disadvantages. It lacks certainty, because what constitutes reasonable use depends, among other things, on the prospective use of all other riparian owners on the stream. Further, the theory allows use of the water only by riparian owners and does not permit diversion for use on nonriparian lands. The doctrine does have the advantage of being flexible as against the prior-appropriation theory. The latter tends to fix the use of water in a permanent pattern which, although it may be in the public interest today, may be considered wasteful in the light of later technical developments.

Ground Water

Legally speaking, ground waters are of two types: those which flow in definite channels, and those without definite channels, classified as percolating waters.* In the Tampa case (*14*), Florida applied the principle of reasonable use to an underground stream, treating it in the same manner as a surface stream. The real problem in such cases is the practical one of proving that the stream has a definite underground channel. Most ground water, however, falls within the percolating-water classification. Concerning the use of such water, there are again three legal approaches. The first of these, the so-called English rule, rests on the concept that he who owns the surface of the earth owns from the center of the earth to the center of the heavens. In a jurisdiction applying this concept, an owner has an absolute right to sink a well on his land and withdraw all the percolating water he can, without regard to the effect on adjoining owners. There is some language in the Tampa case that seems to support this view. The western states differ from the English view and apply the doctrine of prior appropriation to both ground water and surface streams.

In Florida a modification of the English rule has developed and may have become the law. This view, sometimes referred to as the doctrine of correlative rights, parallels the reasonable-use theory, which developed out of the ear-

* For a discussion of the divergence between legal and hydrological concepts of ground water, see the article by Thad G. McLaughlin in this issue (p. 447).—*Editor.*

lier natural-flow doctrine in the case of surface watercourses. Under the correlative-rights theory as applied in some jurisdictions, a taker is limited to his proportionate share of ground water according to his surface area as compared with the whole area overlying the water supply. Other courts have used the term as limiting the taker not on a proportionate basis, but rather on a reasonable-use basis. This interpretation places no limitation upon the quantity of water to be taken so long as the use is reasonable and is made in connection with the utilization of the surface. Under this rule, however, a court may prevent the transfer of ground water from the land from which it is lifted if this operation is detrimental to a neighbor's extraction and use on his own premises.

In two recent cases (*15, 16*) the Supreme Court of Florida has apparently adopted the doctrine of correlative rights with respect to percolating water, but in neither instance was the court concerned with the problem of how much water a defendant could take. The issue of the right of a municipal water works to make unlimited withdrawals was presented in 1953 (*17*). Because of salt water intrusion along the coast, the county-owned Pinellas County water system decided to sink wells in an inland county road right-of-way. The circuit court for the county enjoined the drilling of the wells but did not, however, pass on the basic problem of the amount of water that could be withdrawn. Instead, the court granted the injunction on the ground that the county had only an easement for road purposes and that the abutting owners possessed the fee interest in the road where the wells were to be drilled. The county would therefore be required to condemn a fee interest before it could drill the proposed wells. How much water it could withdraw after acquiring such an interest is still undetermined, but that question may be answered in pending litigation involving another well field in the same system.

It is evident that in ground water, as in surface watercourses, the law of Florida does not provide very definite answers about the amount of water that may be taken by an overlying landowner, nor does the current law give to the first user any assurance that he will be permitted to continue appropriating the same amount of water when later users begin to compete for a limited supply. Moreover, even if the legal rules governing use under the doctrine of correlative rights are formalized, the practical difficulties in establishing the land area overlying the water supply and the extent of the supply itself might place the cost of ground water litigation beyond the reach of the individual landowner. In that event, in areas of shortage, economic competition might well take the place of litigation, with those who could afford the highest lift getting the water. Such has apparently been the experience in parts of California (*18*).

Possible Legislation

One remedy for the uncertainties in Florida's water law would be the replacement of case law with a comprehensive water code. The code could establish a new administrative agency with power to allocate and control the use of water in Florida, perhaps placing usage on a prior-appropriation basis, as has recently been done in Kansas (*11, 19*) and has been suggested in South Carolina (*4*). Such a solu-

tion provides a certain and definite guide for future users, and is, therefore, attractive. Legislative adoption of the prior-appropriation doctrine in the Southeast has been urged (*9*).

Any attempt to change the water law of Florida drastically would raise serious legal problems. The Fourteenth Amendment to the US Constitution provides that no state shall deprive any person of his property without due process of law. The Declaration of Rights of the Florida Constitution contains a similar due-process provision. The common law has traditionally looked upon water rights as property rights rather than rights of use, and such property rights, attached to the land to which they are appurtenant, are not lost through nonuse. Hence, to extinguish water rights legislatively without compensation, by establishing the doctrine of prior appropriation, under which the total supply might go to a prior appropriator, would seem to be a violation of due process of law.

A state does, however, have a right under the police power to regulate various activities of its citizens, including the use of their property, if such regulation is necessary to protect health, safety, and welfare. It is upon this basis that Kansas, where the supply of water is limited, can legally bring about a statutory change from the common-law approach to the doctrine of prior appropriation (*20*). It is one thing, however, to use this justification in a semiarid state like Kansas, and another to argue it successfully in a state like Florida, in most parts of which the supply far exceeds the demand. If an attempt is made to introduce prior appropriation, a preamble to the statute might be helpful. Such a preamble, indicating that changed economic conditions have created an emergency in which the public welfare demands the maximum beneficial use of this natural resource, might provide justification for the legislation. Even so, it seems doubtful that such a law would be held constitutional in Florida under present conditions of water use. It is pointed out, however, that a change to a modified form of appropriation, justified as a legitimate exercise of the police power based on economic necessity, is feasible in Wisconsin, a state with problems like those of Florida (*10*).

An alternative approach is suggested by recent legislation in New Jersey. The legislature in 1947 empowered the division of water policy and supply of the State Dept. of Conservation to delineate areas where diversion of the subsurface and percolating waters exceeds or threatens to exceed the natural replenishment (*19, 21*). In these special areas, the law forbids new withdrawals in excess of 100,000 gal without a permit from the Division of Water Policy and Supply, and the permit may be refused if necessary to conserve the subsurface waters. The law also provides for the sealing of abandoned wells and for supervision of the drilling of new wells in such areas.

A law allowing all landowners to make sufficient withdrawals for domestic use, but regulating excessive withdrawals in designated areas of control while protecting already existing interests, is clearly a justifiable exercise of the police power when limited to critical areas where demand exceeds supply. Moreover, it avoids one objectionable feature of the prior appropriation doctrine: it does not freeze the use of water in what may become an

uneconomic pattern, but is sufficiently flexible to adjust to the changing needs of the times.

Summary and Conclusions

As water use in certain areas of Florida approaches or overruns the available supply, the public interest demands an accommodation of the increasing uses to constant supply, so that the maximum economic advantage, both for the present and future, can be secured from the resource. The attainment of that end will depend upon the state's water law, which will determine whether maximum economic benefits are to be obtained or whether one segment of the economy is to benefit to the detriment of the rest.

The present status of the laws governing use of water in Florida is extremely uncertain. Older case law, enunciated before the turn of the century, adopts the English common-law approach of maximum protection of riparian owners on surface streams while allowing complete freedom of withdrawal to the owners of land overlying ground water supplies. Decisions in later cases seemingly modify these rules by engrafting the principle of reasonable use as a limitation on the landowner's absolute rights, thus making the supply at least partially available for other uses. These rulings, however, have not yet attained the stature of precedent. The resulting uncertainty may have the disadvantage of discouraging potential users whose presence would be of great economic benefit to the state. Because in most areas of Florida, supply still exceeds demand, it may be fortunate that the law has not yet become fixed. Corrective action can be taken if the state becomes aware of the need for laws to encourage the most beneficial use of the available water supply. As more extensive demands are made, there will be a rapidly increasing need to develop an integrated system of laws for controlling the use of both surface and ground water. These laws must be specific enough to encourage maximum use by agriculture, industry, and the public. At the same time they must be sufficiently flexible to permit the state to benefit from technological advances, and must not freeze water use in a pattern that may at some later date prove uneconomical.

A study is now needed to determine and evaluate the existing water law of Florida, both statewide and local. In addition, a thorough study should be made of the water law of those states where the problem became acute at an earlier period and resulted in legislation which has been in operation long enough to be intelligently appraised. Any such study must necessarily include an evaluation of the measures adopted to control pollution which blights the usable supply. These studies would provide the basis for a water doctrine under which the surface and ground water resources of the state could be developed with maximum benefit to the overall economy.

Florida is awakening to the problem. One of the first acts of its new governor has been the appointment of a citizens' committee on water resources. When this committee becomes aware of the need, it may supply the impetus for the development of up-to-date water laws designed to make and keep available Florida's greatest natural resource for the best use of all its people.

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Hydrologic Aspects of Ground Water Law

Thad G. McLaughlin

A paper presented on Nov. 9, 1954, at the Rocky Mountain Section Meeting, Colorado Springs, Colo., by Thad G. McLaughlin, Dist. Geologist, Ground Water Branch, Water Resources Div., US Geological Survey, Denver, Colo. Publication authorized by the Director, US Geological Survey.

IN order to discuss the subject of ground water legislation with maximum competence, one would have to be trained thoroughly in both ground water hydrology and law. As the author is a ground water hydrologist with a limited knowledge of law, this article will be largely devoted to the technical features of ground water legislation.

At least a part of the difficulty in interpreting and enforcing ground water legislation is inherent in the various archaic and arbitrary legal classifications of ground water. The lawyers and the courts are not to blame for this situation, because hydrologists until recent years have not been able to evolve clear classifications. A distinguished water litigation attorney has advised the author, however, that some of the legal classifications of ground water are supported by such weighty judicial precedent that they must continue to be used, even though contradictory to fact.

Definitions taken from two judicial decisions will illustrate the problems involved. One court defined percolating water as "vagrant wandering drops moving by gravity in any and every direction along the line of least resistance." Another court stated: "the physical laws governing underground water and its subterranean progress [are] irregular and unknowable with certainty, and such water [is] changeable and uncontrollable in character [and] subject to secret and incomprehensible influences."

Ground water has been divided into many legal classes, including underground rivers, underground lakes, percolating water, diffused water, defined underground channels, and springs. The author does not know what is meant by these different classes and seriously doubts that anyone else knows either. The first two terms, underground river and underground lake, date back to the period when the subject of ground water was somewhat of a mystery, and people speculated that ground water occurred in the form of rivers and lakes just like surface water. Actually, nearly all ground water is percolating water—that is, it moves by laminar flow—whereas most surface water moves much more rapidly, by turbulent flow. Ground water is controlled largely by geology, surface water by topography, and atmospheric water by temperature and pressure. Hence, it is nearly as logical to say "underground cloud" as it is to say "underground river" or "under-

ground lake." Even in the rare limestone and volcanic-rock terranes where ground water does move in well defined channels by turbulent flow, other factors may make the term "underground river" inapplicable.

The inaccurate legal classification of ground water is, in the author's opinion, the principal cause of the failure of many attempts to regulate ground water use. From a technical point of view, no attempt to set up different classes of ground water is justified. A single drop of water may at one time be percolating water and in a defined underground channel, may subsequently appear as diffused surface water or in a spring, or may even contribute to the base flow of a surface watercourse; it is evident, therefore, that the legal classifications of ground water are unworkable.

Ground and Surface Waters

It is also problematical whether there should be a distinction between ground water and surface water. The terms ground water, surface water, and atmospheric water do not apply to permanent states of water but merely represent water at a particular stage of the hydrologic cycle. A single drop of rain falling to earth may move into a stream and become surface water. A short distance beyond, it may be lost through the stream channel to become ground water, and a short distance farther, it may return to the stream. There is a continual interchange of ground and surface water, and the base flow of nearly all perennial streams is maintained by the discharge of ground water. There does exist one fundamental difference between ground and surface water, however, which is important in ground water legislation: runoff in streams can be measured with some degree of accuracy, and when all the water in a stream is appropriated, the fact is obvious to everyone. The increment of the ground water supply, known as recharge, is roughly analogous to surface water runoff, but there is also the factor of storage, which is not involved in surface water under natural conditions. In many places, large quantities of ground water have been stored in underground reservoirs for periods of thousands of years. When pumpage is sizable, it brings up the question of whether the recharge alone is being withdrawn or whether the storage is being depleted. The problems faced by formulators of ground water legislation can best be illustrated by discussing situations in areas where detailed information is available.

Low-Recharge Storage

The High Plains area has little natural recharge. This region is underlain by the Ogallala formation, a very productive aquifer. It extends from the Black Hills of South Dakota to the southern part of the Texas Panhandle and includes parts of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas. The area comprises about 156,000 sq miles (about the size of California), and the underlying aquifer is believed to have in storage about two billion acre-feet of ground water.

The region is almost everywhere surrounded by land at lower elevations. Thus, ground water moves away from the plains, and the ground water source must be the precipitation within the plains. This averages only about 20 in. a year, and only a very small percentage reaches the water table, so that the recharge is very low. It is believed to range from less than ¼ in.

annually in parts of Texas and New Mexico to as much as 3 in. in part of the sand hills area of Colorado and Nebraska.

In the High Plains of Texas, farmers pump nearly 5,000,000 acre-ft of ground water a year in an area where the annual recharge is believed to be less than 100,000 acre-ft. Furthermore, a comparable amount of natural discharge also occurs. Although the water is being mined rapidly, the supply has already lasted 20 years and may last several decades longer, enough time for the repayment of most existing investments. Meanwhile the area is enjoying a prosperity not otherwise possible.

In the central and northern High Plains, the aquifer has not been developed to any such extent, and there is the problem of how it should be developed. It does not seem feasible to develop only the recharge and save the storage. In the first place, the recharge in any aquifer cannot be fully developed until the water levels are lowered. Then the question arises as to who is entitled to the stored water that is pumped out while the water table is being lowered. In the second place, it is difficult to take the recharge without also taking the storage. Before man diverted water and drilled wells, most aquifers were in equilibrium—that is, the discharge from an aquifer over a period of years was equal to the recharge to the aquifer. Because there is little fluctuation of the water level in the aquifer in the central and northern High Plains, hydrologists know that the aquifer is still essentially in equilibrium. In order to salvage the recharge, the discharge must also be captured. If an amount equivalent to the recharge is pumped and the discharge is not stopped, the water levels will decline, and water will be withdrawn from storage.

The Frenchman Creek area in northeastern Colorado is a region where recharge alone cannot be pumped. All recharge on one side of the ground water divide moves eastward across the state line. The amount of ground water flowing across the state line annually is equivalent to the annual recharge to the ground water reservoir. It has been determined that the underflow across the state line is on the order of 100,000 acre-ft a year, equivalent to slightly less than 1 in. of recharge annually in the area. Suppose it were decided to pump only the recharge of 100,000 acre-ft annually. A withdrawal of 100,000 acre-ft of water uniformly throughout the area would lower the water table over the whole region less than ½ ft. The thickness of water-bearing materials at the state line averages about 200 ft. The withdrawal of 100,000 acre-ft of water, if uniform, would not change the hydraulic gradient appreciably. The withdrawal would only reduce the thickness of the section through which the water is flowing at the state line from 200 ft to 199½ ft. Consequently, the discharge would be reduced by about one part in 400. Only about 250 acre-ft of recharge would be salvaged, and the remainder of the 100,000 acre-ft of water would come from storage. In an aquifer of this type, it appears that there is no choice but to mine the water.

High-Recharge Storage

The storage problem is considerably different in areas where the recharge is high—for example, where large amounts of surface water are spread on the land for irrigation. In the Closed Basin in the San Luis Valley,

Colo., about 300,000 acre-ft of surface water is diverted to the land annually for irrigation. During periods of low stream flow, nearly a thousand wells have been drilled to supplement the water supply. In 1951 the stream runoff reached a record low, and wells pumped nearly 300,000 acre-ft of ground water, resulting in an average water table decline of several feet. During the following year the available surface water supply was above normal, very little ground water was pumped, and the ample artificial recharge returned water levels to normal. This area has an ideal combination of surface and ground water use. Also the ground water reservoir serves as a nearly evaporation-free reservoir to be called upon in times of surface water shortage. It would be disadvantageous to mine the ground water in this region. If the ground water is developed only to the extent of the artificial recharge, it will last as long as that recharge does. Moreover, the natural recharge can be partly salvaged, because this water is now being dissipated by evapotranspiration, which can be reduced by lowering the water table. There are similar situations in the Arkansas and South Platte valleys, where large quantities of surface water are available for recharge.

Surface and ground water uses should be coordinated in many areas rather than permitted to conflict. There are sections, for example, where it may be wise to abandon the use of surface water and do all irrigating by wells. In the Arkansas Valley in western Kansas, between Hartland and Garden City, the river normally flows throughout the year. During the 1930's, however, when stream flow was low and the withdrawal of water from wells was large, the water levels declined 5–10 ft, enough to cause the river to go dry. A single flood in 1941 caused the water levels to return to normal and the stream to flow again. Records show there was a loss of stream flow in that reach of the river amounting to about 75,000 acre-ft. In other words, by using ground water and lowering the water level below that of the stream bed, there was a saving of 75,000 acre-ft that otherwise would have gone down the river. In many places where the supply of surface water is small and not too dependable, it may be well to substitute pumping in order to lower the water table and capture water by channel infiltration that would otherwise go on downstream.

Lift

A major problem to consider is whether there should be a vested right in lift. Water cannot be withdrawn from an aquifer without lowering the water level. It is impossible to pump a large number of wells in a field without causing each well to affect the water levels in the others. If there is a vested right in lift, the well owner second in time would have to pay tribute to the first, and so on down the line until the latest comer would be paying tribute to all. It seems clear, therefore, that a vested right in lift is usually impractical. There is, however, a problem of conflicting uses of water. For example, it is questionable whether an industry that can operate profitably with a lift of 500–1,000 ft should be allowed to lower the water level excessively in an area where the farmer's economic limit of lift is only 150–200 ft. The same conflict probably would arise between large and small farm operations. Another problem in connection with lift is the maintenance of

artesian flow. The San Luis Valley for example, is filled to a depth of more than a mile with sediments consisting mainly of alternating layers of clay and of sand and gravel. The layers of clay impede the upward movement of water, developing artesian pressures. Water from any of the beds of sand and gravel below about 100 ft will rise to the surface and flow. The farmers in that area are drilling ever deeper wells to tap those flows. A number of recent wells are 1,000–2,000 ft deep. The great cost of developing these wells is partly compensated by the fact that the water flows at the surface and there is no pumping expense. It appears that, in such situations, it may be necessary to protect the right in lift (or in lack of lift) in order that it may continue to be economically feasible to tap the deeper aquifers.

Effect on Streams

A touchy problem is what to do about well users who take water that would otherwise reach a stream on which there are water rights predating those of the wells. Before ground water codes can be administered properly, there will have to be considerable new thinking on this subject. In Colorado, for example, the courts have ruled that ground water users cannot take water that is tributary to a stream, and that the burden of proof is on the pumper. If this rule were enforced strictly, almost all pumping would cease, for nearly all ground water is tributary to a stream or is moving toward a stream. Much of it never reaches the stream but is lost by evapotranspiration on route.

The ground water along the western edge of the High Plains in Colorado is moving toward Big Sandy Creek, but it is doubtful if more than a few gallons in a thousand ever reaches it. Much of the water is consumed by relatively useless vegetation. To protect the few gallons of eventual surface water the remainder would have to go to waste.

In the Frenchman Creek area of Colorado and Nebraska, it has been found that the development of about 100,000 acre-ft of ground water annually would deplete the flow of the creek by about 15,000 acre-ft per year. In order to use the water most efficiently, therefore, it may be necessary to make an adjustment for 15,000 acre-ft in surface water rights, so as to salvage 85,000 acre-ft of ground water taken from storage and recharge.

In Beaver Valley, Colo., no surface water supplies are available, and irrigation is entirely by wells. The ground water, however, moves toward the South Platte River, and part of it eventually reaches the stream. If the users of surface water in the South Plate Valley were to be protected fully, all pumping in Beaver Valley would have to be stopped. The pumpage in the valley averages about 20,000 acre-ft annually. The underflow into the South Platte Valley is about 8,600 acre-ft annually. As the water levels have declined, the underflow has also declined by probably less than 1,000 acre-ft annually. The pumping of 20,000 acre-ft annually would have to be stopped in order to prevent interference with 1,000 acre-ft of surface water rights.

When irrigation from wells was begun intensively in the South Platte Valley in the 1930's, there was great concern that the wells would cause the river to go dry. There has been no serious lowering of the water level in the valley, even though the pumpage of ground water may exceed 750,000

acre-ft in dry years. Furthermore, a large part of the land would have been waterlogged if the ground water had not been pumped.

Conclusion

As water demands increase and supply problems become more critical, far-reaching steps will have to be taken for the most efficient utilization of the available supply through careful co-ordination of the use of ground water and surface water. The degree of co-ordination that can be achieved within the framework of present and future legislation will determine how successful the effort will be.

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Detroit Experience With Sulfur Compound Jointing Material

Leo V. Garrity

A paper presented on Sep. 10, 1953, at the Ohio Section Meeting, Cleveland, by Leo V. Garrity, Asst. Gen. Mgr. & Chief Engr., Dept. of Water Supply, Detroit.

THIS paper reports findings in an investigation of failures in underground cast-iron pipe in relation to the jointing materials used. The supporting data were obtained from tests and investigations made during the spring and summer of 1949. These studies constitute only one phase of continuing comprehensive and intensive research (initiated in 1941) into the many factors that may contribute to cast-iron pipe failures experienced in the Detroit water system.

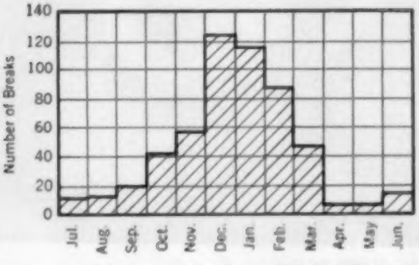

Fig. 1. Detroit Cast-Iron Main Breaks

The figures shown are 5-year averages for each month, July 1948–June 1953

There are over 3,000 miles of cast-iron water pipe within the limits of Detroit. About 2,500 additional miles outside the city limits comprise the systems of various communities furnished water by the department. Intensive studies have been confined to the water system within Detroit, where the department has complete control.

Incidence of Main Breaks

The annual number of breaks occurring in the underground cast-iron pipe in the city system averages about 20 per 100 miles of pipe of all sizes. The incidence of breaks in the 6-in. and 8-in. diameter pipe, however, is consistently the highest. The averages are 22 and 30 breaks per 100 miles of 6-in. and 8-in. pipe, respectively, per year. The work described was confined to 8-in. diameter pipe in the hope that this study would return a maximum of information for the effort and expense allocated to this phase of the investigations.

The number of breaks occurring in underground cast-iron pipe in the system is at a maximum during December–March and at its lowest during the spring and summer (Fig. 1). The temperature of the water in

the mains may be as low as 34°F during the cold months and as high as 76°F in July and August. Thus, the pipe may be subjected to a temperature variation of 42°F during the year.

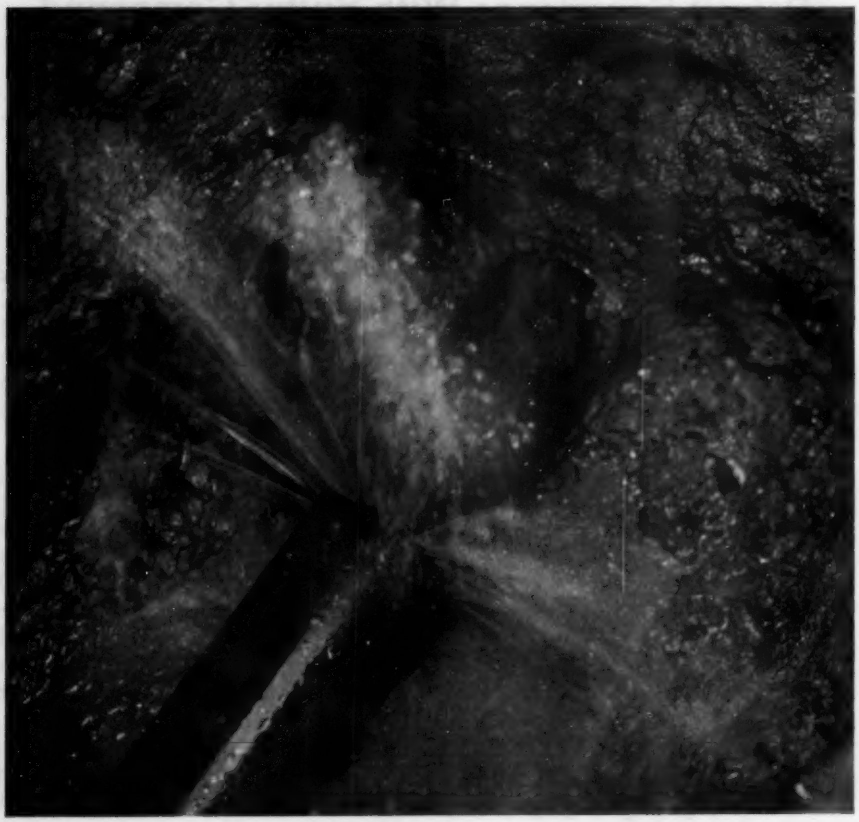

Fig. 2. Circumferential Break

This photograph was taken while the 8-in. main shown was under reduced pressure.

Type of Breaks

The majority of breaks follow the same pattern. Observation has disclosed that a typical form of circumferential break is found in pipe laid in the last 30 years. Examples are shown in Fig. 2 and 3. Almost invariably the fractures are associated with localized corrosion. The planes of the breaks are, in most instances, very nearly perpendicular to the longitudinal axis of the pipe. This indicated tension failures, which, in turn, suggested the existence of significant fixity at the pipe joints. It was decided, therefore, to investigate pipe joints of various ages cut from 8-in. lines in service. All pipe from which samples were taken was bell and spigot, Class 150, centrifugally cast in metal molds except for one with

lead as the jointing material. None of the spigot ends had beads in the joints, except No. 8, which had lead as the jointing material and was 23⅓ years old.

Securing Specimens

A lifting frame was provided in order to insure that the joints in the pipe cut from the water system would not be disturbed during removal and until tests were started. This frame may be seen in Fig. 4. The joints to be removed were selected from unbroken pipe near breaks. The joints were carefully exposed by hand excavation. The frame was placed in position and bolted, and the cradle blocks were wedged and fixed before pipe cutting was started. The whole assembly was then carefully transported intact to the test site. Each joint was kept moist by means of clay and wet burlap from the time of exposure to the start of the tests.

At the test site, the cut ends of each test piece were closed by 6-in. pipe caps. The caps were machined to 9⅛-in. ID to receive the 8-in. pipe ends. One cap in each setup was drilled and tapped for a connection to a test pump, and the other for an air vent. The caps were then brazed to each piece, after which pull-out tests were conducted.

A pump of 2,000-psi capacity, equipped with a test gage, was connected to the test piece and the water supply line. The specimen was filled with water, care being used to expel all air. After the air vent had been

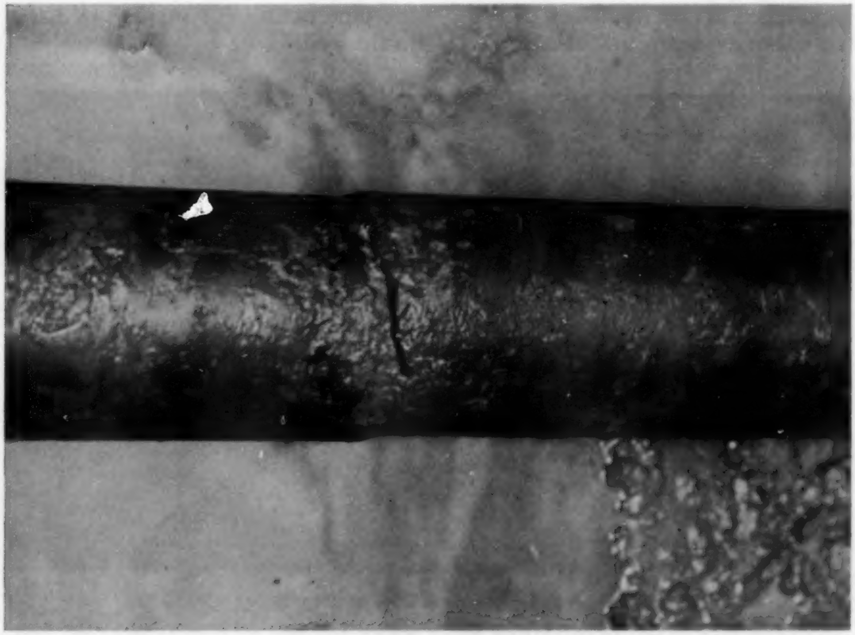

Fig. 3. Circumferential Break

The 6-in. cast-iron main shown here was laid in 1927.

closed, all restraint against longitudinal movement of the specimen was taken away, leaving only restraint due to friction on the support blocks. A dial indicator, mounted across the joint on a horizontal bar, was set to indicate movement across the joint due to applied hydrostatic pressure. The pressure was applied slowly, and simultaneous readings of the pressure and indicating gages were taken until the joint failed. The results of the pull-out tests are shown in Table 1.

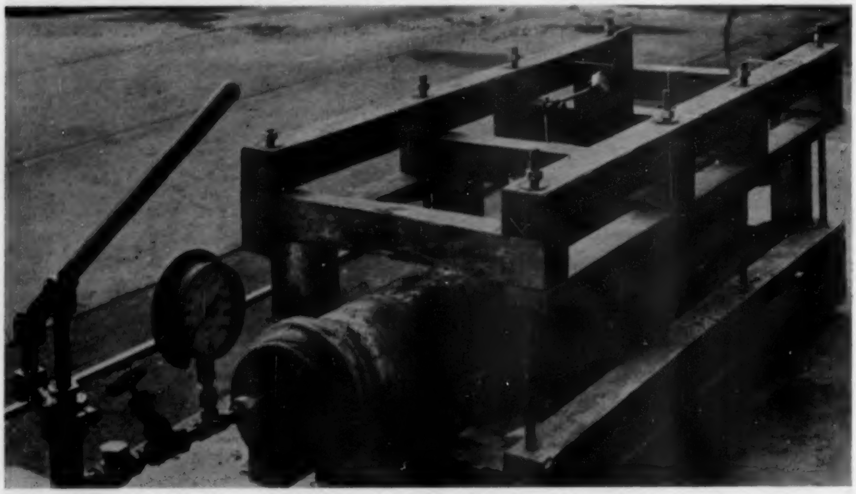

Fig. 4. Pull-out Test Apparatus

The pipe is still in the lifting frame which has held it since excavation.

Results of Tests

Specimen No. 6, the 1-day lead joint specimen, had no bead on the spigot in the joint, while the spigot of specimen No. 8, which was cut from the system after 23⅓ years in service, had a bead. The two lead-jointed specimens tested showed movement across the joints at the lowest load increment, the existing system water pressure of 60 psi. In both, the movement at that increment of test load was 0.001 in. Age, therefore, had no apparent effect on the plastic flow of the lead. Actually, the lead joints in these tests started to yield at the lowest pressure, and the joints moved freely with every increment of load up to the pressures where significant leakage started, which were noted as failure points. There was no elastic deformation in the pipe itself. All slippage occurred in the lead.

In the specimens with sulfur compound joints, the deformations measured up to the failure point of the jointing material checked very closely with the calculated elastic values. Failures occurred in the sulfur compound joints on fracture planes having inclinations 45–60 deg to the longitudinal axis of the pipe and were accompanied by noise described as sharp reports. Data in the last column of

Table 1 indicate the uniformity of strength found in the sulfur joints. The variation from the mean of the lowest value is about 15 per cent, and that of the highest is less than 10 per cent. This seems remarkable because the youngest joint tested was 24 hr old, and the oldest over 21 years. The joint tested 1 day after it had been poured was made up under what might be described as laboratory conditions, while the others were made by various personnel over a 21-year period under field conditions.

For a probable temperature differential of 42°F, the restraining force necessary to prevent movement of the pipe would be equal to the induced stress multiplied by the cross-sectional area of the pipe wall. For pipe having a wall thickness of 0.38, the force would amount to approximately 34,118 lb. The restraining force set up by the sulfur compound joint was measured at 45,600 lb. This was about 33 per cent more than necessary to stress the pipe metal the full amount possible from temperature effect.

TABLE 1

Pull-out Tests of 8-in. Pipe Joints

Specimen	Jointing Material	Specimen Age		Avg Depth of Jointing Material *in.*	Applied Load		Total Load *lb/in.**
		yr	*days*		*psi*	total *lb*	
5	sulfur compound	0	1†	3.0	840	47,880	15,960
7	sulfur compound	4½		2.5	540	30,780	12,314
3	sulfur compound	10½		3.75	940	53,580	14,290
2	sulfur compound	14½		3.25	850	48,450	14,900
1	sulfur compound	21½		3.00	800	45,600	15,200
6	lead	0	1†	3.0	200	11,400	3,800
8	lead	23½		2.75	240	13,680	4,980

* Pounds per inch of depth of jointing material.

† Prepared under laboratory conditions.

An analysis of the test results for specimen No. 1, cut from pipe having over 21 years of service, will illustrate the significance of the magnitude of restraint or fixity that the sulfur compound produced in the pipe joints. The average measured thickness of the specimen pipe wall was 0.38 in. for both the spigot and bell pieces. The modulus of elasticity, determined from tests of iron specimens taken from similar pipe of the same age, was taken at 14,000,000 psi. The coefficient of expansion was taken as 0.0000058 per degree Fahrenheit.

If the particular pipelines from which the test specimens were taken had suffered corrosion of the type and degree illustrated in Fig. 2 and 3, the induced temperature stresses might have become the immediate cause of the typical failures experienced. Each specimen removed from the system was examined carefully to determine the condition of the jointing material and of the adjacent pipe. The observations are shown in Table 2.

The jointing material in specimens No. 2, 3, and 7 had a light-to-dark gray cast throughout. The compound

in specimen No. 1 showed a light-gray sheen, except at the fringe, where slight disintegration had set in. The color of the material in the disintegrated fringe ranged from brown to black. The 23½-year-old lead joint, specimen No. 8, showed no apparent deterioration, and the adjacent pipe showed no evidence of corrosion.

Use of Sulfur Compound

The Detroit water department first used a sulfur compound as a jointing material in 1919. For the next 6 years all joints up to and including those in 24-in. pipe were made with a compound supplied by a manufacturer who has long since gone out of that business. Almost all joints poured during that period have failed and have been replaced. The most recent replacement, involving 5,000 ft of 24-in. diameter pipe, was made in 1950. The joints composed of this material totally disintegrated, and the substance had the appearance of spent foundry sand.

From 1925 through 1952 all sulfur compound jointing material was obtained from one supplier, and its use was confined to pipe of 12-in. diameter and smaller. The sulfur compound joints in the specimens tested were made from this material.

Hidden Corrosion

There is another kind of corrosion found in cast-iron pipe, besides that illustrated (Fig. 2, 3). In this type, corrosion progresses beneath the thin metal of the outer surface without manifestations on the outside of the pipe. Such corrosion leaves an interior structure in the pipe walls comparable, in some respects, to that of timber after an attack by termites. With this type of corrosion, temperature-induced stresses may be the immediate cause of tension failure.

Evidence of the following phenomenon, now quite generally recognized, has been found in the Detroit system. Certain types of corrosion in buried cast-iron pipe may proceed for some time at high rates until inhibited or entirely stopped by the protection offered by corrosion products formed in the process. Examples of this phenomenon are usually found in the older Detroit lines, one of which has been in service since 1838. These lines have lead joints and generally have greater wall thicknesses than the pipe included

TABLE 2

Condition of Jointing Material and Adjacent Pipe

Specimen	Time in Service *yr*	Condition of Joints	Condition of Adjacent Pipe
7	4½	excellent*	no corrosion
3	10½	excellent*	no corrosion
2	14½	excellent*	exterior surface of spigot, in joint, shows slight corrosion
1	21½	slight disintegration at fringe of exposed face of joint in contact with bell; no evidence of leakage	complete ring of corrosion $\frac{1}{16}$-in. deep, ¼-in. wide at junction of joint compound and packing on exterior surface of spigot

* No disintegration or evidence of leakage.

in tests described in this article. Where such self-protection occurs, the pipe may last indefinitely if sufficient metal remains to withstand any imposed stresses. The additional stress that may be produced through joint restraints can be evaluated in terms of equivalent metal. In the foregoing analysis, the induced temperature stress, alone, is the equivalent of a loss of about 15 per cent of the total metal in the pipe wall.

Types of Detroit Soils

In general, the soils in the Detroit area are quite typical of those of other cities situated on the Great Lakes. Mains are laid in sand, mixed fills, yellow clay, and blue clay. There is no rock at the depths where the mains are placed. The range of pH for the soils so far investigated is 6.5–7.9, with acidity varying from 0.8 to 20.0 milliequivalents per 100 g of soil. The lowest acidity value on record was found adjacent to a main break in a brick-and-ash fill, with pH 7.6. The highest value was obtained in yellow clay of pH 6.8. The corrosion index * varies from a low of 0.2 for yellow sand (pH 6.5) to a high of 1.2 for a mixture of yellow sand and blue clay (pH 7.5). Numerous samples of soils surrounding the mains have been tested to determine the role that anaerobic bacteria action may have played in corrosion. At six locations tests for sulfate-reducing organisms were positive.

* 24 hr, 2 v (*1, 2*).

Conclusion

The investigations described here have shed some light on the relationship of water temperatures to the incidence of breaks in underground cast-iron pipe. Once pipe corrosion starts, it continues to remove metal and reduce wall thickness unless the environment changes or the process is stopped by the corrosion products themselves. Where corrosion is active, it may be expected that pipe walls are continually being reduced in thickness. Eventually the superimposed stress caused by restraint against temperature induced movement causes pipe failure. Every year, sections of weakened pipe which had not quite reached the critical metal loss in the preceding year give way.

It is believed that the economic life of cast-iron pipe in underground service, subjected to corrosion, can be extended by providing for freedom from restraint in the joints.

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Discussion

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An analysis of pipeline failures in the Indianapolis system shows a similarity to the pattern of experience at Detroit as reported by Garrity. Although the frequency of breaks is much higher at Detroit, the relationship between temperature change and pipe breaks in lines using sulfur compound

TABLE 3—*Pipeline Failures in the*

Description or Cause	Year of Repair													
	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
	Pipe Failures													
Cast iron														
Transverse break*	3	4	4	3	3	—	1	2	2	6	3	3	3	—
Electrolysis	4	4	5	—	—	—	2	1	2	—	3	3	1	—
Construc. accident	—	—	3	—	3	1	—	—	—	—	1	1	1	1
Defective pipe	—	1	1	—	—	—	—	1	—	—	1	—	5	—
Corrosion (cinders)	—	—	—	—	1	—	—	1	1	—	1	3	—	1
Sidewall failure	—	—	—	—	—	—	—	2	—	—	3	—	—	1
Hydrant branch†	—	—	—	—	—	—	—	—	2	—	—	—	1	2
2-in. tap	—	—	—	—	—	—	—	—	—	—	1	—	—	2
Bell crack	—	—	1	—	—	—	—	—	1	—	—	—	—	—
Bedding fault	—	—	—	1	1	—	—	—	—	—	—	—	—	—
Vibration	—	—	2	—	—	—	—	—	—	—	—	—	—	—
Frozen‡	—	—	—	—	—	—	—	—	—	—	1	—	—	—
No record	—	—	1	—	—	1	—	2	—	—	—	—	—	—
Miscellaneous	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Steel														
Corrosion	—	—	—	2	—	—	—	1	1	3	2	2	—	2
Miscellaneous	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Total	7	9	17	6	8	2	3	10	9	10	17	12	11	9
Mains at yr. end—*mi*	569	589	609	633	655	658	659	659	659	660	661	670	679	692
Failure Ratio§	1.23	1.38	1.87	1.63	1.54	1.32	1.19	1.23	1.25	1.28	1.40	1.43	1.45	1.44
Location	Pipeline Failures													
Joint	34	42	46	58	39	42	42	35	37	27	48	21	45	36
Pipe	7	9	17	6	8	2	3	10	9	10	17	12	11	9
Total	41	51	63	64	47	44	45	45	46	37	65	33	56	45

Item	Failures by Sizes of Pipe, 1950–1954								
	2½ in.	4 in.	6 in.	8 in.	12 in.	16 in.	20 in.	24 in.	Total *no.*
Sulfur compound joints	—	—	26	21	63	38	27	5	180
Transverse pipe breaks									
Sulfur compound joints	—	—	54	6	1	0	0	0	61
Non-sulfur compound joints	9	6	17	4	0	1	0	0	37
Pipe with sulfur compound joints‖—*mi*	0	0	172	85	59	17	9	1	343

* Settlement or contraction. † Caused by collision. ‡ Excludes 19 others in 1936.
§ Cumulative average failures per 100 miles of main. ‖ Estimated.

joints is the same in both systems. In addition, a similar relationship between sulfur compound joint failures and temperature changes is shown by the Indianapolis record.

The analysis presented in Tables 3 and 4, leads, therefore, to the conclusion reached by Garrity: sulfur compound is much too rigid for use as a jointing material in bell-and-spigot pipe when the pipeline is subjected to considerable variation in water temperatures. The rigid joints allow stresses to build up in the lines that can exceed the yield point of the pipe or the jointing material itself. Failure then will occur in one or the other, depending on which is the weaker or in the greater stress at the moment. Obviously, many of the failures that have

Indianapolis Distribution System, 1926–1954

Year of Repair															
1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	Total
Pipe Failures															
3	6	5	6	8	11	6	9	14	4	11	20	12	25	30	207
—	1	—	—	—	—	—	2	—	—	—	—	1	1	—	30
—	—	—	—	1	—	—	6	6	11	11	13	14	9	37	119
—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	11
—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	9
—	—	1	—	1	1	2	2	3	2	—	—	6	5	2	31
—	1	1	—	—	1	—	—	1	1	2	1	3	2	1	19
2	—	1	—	—	—	—	1	—	—	—	—	1	1	—	9
1	—	—	—	1	2	—	2	—	1	3	1	1	2	—	16
—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	3
—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	2
—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	6
—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	2
—	2	2	4	1	1	1	2	1	1	2	2	—	2	1	35
2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	5
8	10	11	10	12	17	10	24	26	21	31	38	39	48	72	507
704	720	729	729	731	738	752	783	817	864	901	926	950	976	1,020	
1.41	1.41	1.42	1.42	1.43	1.48	1.47	1.55	1.64	1.68	1.77	1.89	2.02	2.14	2.37	
Pipeline Failures															
40	50	49	61	42	32	44	25	51	59	45	64	66	49	54	1,283
8	10	11	10	12	17	10	24	26	21	31	38	39	48	72	507
48	60	60	71	54	49	54	49	77	80	76	102	105	97	126	1,790

Failures Repaired by Months, 1950–1954

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total *in.*
8	8	7	15	32	27	8	9	7	21	25	13	180
11	4	2	0	0	0	0	0	1	4	8	31	61
10	4	1	1	0	2	1	2	0	2	3	11	37

occurred have been influenced or caused entirely by outside factors, such as external loading on the pipeline, loss of metal by external or internal corrosion, flaws in the pipe metal, faulty joint construction, or deterioration of the jointing material by soil acids or sulfur bacteria. On the other hand, many failures that occurred with outside factors present would not have occurred except for the addition of internal stressing.

The pattern of failures in sulfur compound joints would definitely indicate that they result from stress fatigue caused by alternate compression and tension when the pipelines expand and contract. The joint failures have occurred predominately in the large sizes and the pipe breaks have been confined

TABLE 4—*Joint Failures in the*

Year Installed	Year of Repair													
	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
	Sulfur Compound Joints													
1924	—	2	8	9	6	4	10	6	9	9	11	3	8	4
1925	1	1	8	3	2	1	1	2	3	5	4	1	—	3
1926	2	—	—	3	1	—	—	—	1	1	1	—	1	1
1927	—	2	2	1	1	1	3	1	2	2	1	1	2	—
1928	—	—	—	1	—	—	—	—	1	—	—	1	—	2
1929	—	—	—	2	—	—	2	—	1	—	—	—	—	1
1930	—	—	—	—	1	—	—	—	—	—	—	—	2	2
1931	—	—	—	—	—	—	—	—	—	—	1	—	—	—
1932	—	—	—	—	—	—	1	—	—	—	1	—	—	—
1935	—	—	—	—	—	—	—	—	—	—	—	—	1	—
1936	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1937	—	—	—	—	—	—	—	—	—	—	—	—	1	1
1938	—	—	—	—	—	—	—	—	—	—	—	—	1	—
1939	—	—	—	—	—	—	—	—	—	—	—	—	—	1
1940	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1941	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1942	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1943	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1944	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1945	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1946	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1947	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1948	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1949	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1950	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	3	5	18	19	11	6	17	9	17	17	19	6	16	15
Joints														
At yr. end—*1,000*	43	53	63	75	86	87	88	88	88	88	89	93	96	101
Avg age—*yr*	2.1	2.7	3.3	3.8	4.3	5.2	6.2	7.2	8.2	9.1	10.1	10.6	11.3	11.7
Accum. avg age—*yr*	0.3	1.1	2.6	3.0	3.4	3.7	4.2	4.7	5.3	6.0	6.7	6.9	7.2	7.5
Failure ratio†	0.071	0.084	0.159	0.194	0.177	0.154	0.161	0.152	0.155	0.162	0.167	0.157	0.158	0.157
Failure ratio‡	0.111	0.094	0.101	0.153	0.129	0.106	0.104	0.094	0.097	0.098	0.100	0.093	0.094	0.097
	Lead Joints													
Joints at yr. end—*1,000*	242	242	242	242	242	242	242	242	242	242	242	242	242	242
Failures	31	37	28	39	28	36	25	26	20	10	28	15	29	21
Age of joints—*yr*§	25.6	28.0	29.1	31.1	31.7	33.1	32.7	33.0	33.3	33.0	33.4	33.9	34.3	34.4
Failure ratio‖	0.128	0.140	0.139	0.139	0.135	0.137	0.132	0.129	0.124	0.116	0.116	0.111	0.112	0.110
	Mechanical Joints													
Joints at yr. end—*1,000*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Failures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Miscellaneous Joints													
Failures	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Total failures	34	42	46	58	39	42	42	35	37	27	48	21	45	36

* At failure.
† Cumulative failures per year per 1,000 joints.
‡ Cumulative failures per year per 1,000 joints, excluding joints installed in 1924.
§ Cumulative average age at failure.
‖ Cumulative failures per year per 1,000 joints.

Indianapolis Distribution System, 1926–54

Year of Repair															Total	Leak Ratio#	Joints Installed —*1,000*
1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954			
Sulfur Compound Joints																	
4	8	14	7	9	13	10	6	13	9	14	14	9	7	5	231	0.49	15.5
1	3	11	13	6	1	9	3	7	7	3	2	9	3	5	118	0.24	16.5
2	—	1	1	2	1	1	1	1	1	1	1	3	1	2	30	0.10	10.5
1	—	1	2	1	1	1	2	1	1	1	4	2	3	1	41	0.15	10.0
—	4	—	3	1	—	1	—	3	3	—	2	4	—	1	27	0.10	10.0
—	—	—	1	3	1	2	1	3	4	—	2	1	1	1	26	0.09	12.0
—	2	—	6	4	5	2	3	4	4	5	12	10	5	5	72	0.27	11.0
—	—	—	—	—	—	—	—	—	3	1	—	—	1	1	7	0.20	1.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.18	0.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	0.11	0.5
—	—	—	—	—	—	—	—	—	—	1	1	2	2	1	7	0.76	0.5
1	—	—	1	—	—	—	—	—	—	—	—	—	1	—	5	0.06	4.5
—	1	2	2	1	—	—	—	—	1	—	2	—	1	1	12	0.23	3.2
—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2	0.03	4.6
—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	2	0.03	4.4
—	1	—	—	—	—	—	1	—	—	—	—	—	—	2	4	0.05	5.9
—	—	—	—	1	1	1	1	—	—	—	3	—	—	—	7	0.14	4.0
—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	0.87	0.1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.00	0.9
—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	0.04	2.4
—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2	0.05	5.2
—	—	—	—	—	—	—	—	2	—	—	—	1	—	1	4	0.04	12.4
—	—	—	—	—	—	—	—	2	3	2	1	2	1	—	11	0.12	13.6
—	—	—	—	—	—	—	—	—	2	1	3	1	2	3	12	0.12	17.4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.00	1.0
9	19	29	37	28	23	27	19	36	40	30	48	44	28	30	625		
105	112	115	115	116	118	124	136	150	167	168	168	168	168	168			
12.2	12.6	13.2	14.1	15.0	15.5	16.1	15.6	15.2	14.6	15.5	16.5	17.5	18.5	19.5			
7.8	8.4	9.3	10.2	10.8	11.4	12.0	12.4	13.0	13.6	14.1	14.7	15.4	15.7	16.1			
0.151	0.153	0.160	0.172	0.177	0.177	0.181	0.178	0.182	0.186	0.186	0.192	0.208	0.218	0.229			
0.094	0.095	0.100	0.115	0.121	0.117	0.119	0.117	0.120	0.125	0.123	0.129	0.143	0.152	0.162			
Lead Joints																	
242	242	242	242	242	242	242	242	242	242	242	242	242	242	242			
31	31	20	24	14	9	17	6	15	17	14	12	17	15	11	626		
35.4	36.1	36.2	36.6	36.9	37.0	37.4	37.2	37.6	38.2	38.4	38.7	39.2	39.6	39.8			
0.111	0.112	0.111	0.110	0.107	0.104	0.102	0.099	0.097	0.096	0.095	0.093	0.092	0.091	0.089			
Mechanical Joints																	
—	—	—	—	—	—	—	—	—	0.75	15.2	25.0	34.9	45.0	62.5			
—	—	—	—	—	—	—	—	—	—	—	4	2	4	5	15		
Miscellaneous Joints																	
—	—	—	—	—	—	—	—	—	2	1	—	3	2	8	17		
40	50	49	61	42	32	44	25	51	59	45	64	66	49	54	1,283		

Cumulative leaks per year per 1,000 joints.

primarily to the small sizes. Further, the failures have taken place primarily when water temperatures were reaching maximum variations. This shows that internal stressing is a major factor. The analysis does not produce any other pattern of failure that could be associated with some other definite cause.

In Table 3 the month of repair of joint failures does not necessarily indicate the month of failure because frequently there has been an interval between the occurrence of failure and surface indications of it. Except in rare instances, pipe breaks have given

TABLE 5

Failures During 1949–54, by Types of Joints

Year of Pipe Installation	No. of Breaks	Type of Pipe	Type of Joint
1881–1923	27	pit cast	lead
1924–1937	4	pit cast	sulfur
1938–1949	56	centrifugally cast	sulfur
1950–1954	2	centrifugally cast	mechanical
Total	89		

immediate surface indications. Of the transverse breaks in bell and spigot pipe, 68.5 per cent (excluding nine breaks in 2¼-in. cast-iron screw-thread pipe) during 1949–54 have occurred in lines laid with sulfur compound joints (Table 5). In the five cold months, October–February, 90 per cent of these failures took place. Water temperatures have varied as much as 50°F between summer and winter.

Pipelines 12 in. in diameter and larger have had 75 per cent of the sulfur compound joint failures, during 1949–54. In the second quarters of these years 41 per cent were repaired, and in the fourth quarters 33 per cent were repaired. Mechanical-joint repairs have been limited to tightening of loose bolts and replacement of a few broken follower rings. In 1954 there were 37 (51.5 per cent) pipe failures due to construction accidents during work on enlargement of the sewer and street systems.

Inasmuch as the frequency of pipe breaks has accelerated during the past several years simultaneously with the diminishing of the incidence of sulfur compound joint failures, it can be concluded that the pipe is losing tensile strength, possibly because of a corrosion factor. This would agree with the experience at Detroit where external corrosion has caused a loss of metal to a point that it is a factor in breaks. Corrosion in Indianapolis is internal rather than external, and this problem has been solved by the use of cement lining. The record of only two pipe breaks in mechanically jointed lines since inception in 1949 confirms the original opinion that this type of joint has a decided advantage in reducing pipeline maintenance.

The much higher frequency of breaks in Detroit indicates that some outside factor exists that is not present at Indianapolis. If all factors present are common, however, then they exist in a much higher degree at Detroit. Garrity has certainly made a very thorough approach to his problem and he is to be commended for the work accomplished. It provides a substantial contribution to the study of causes of pipeline failures.

Factors Causing Main Failures

Frank E. Dolson

A paper presented on Sep. 28, 1954, at the Missouri Section Meeting, Jefferson City, Mo., by Frank E. Dolson, Distr. Supt., St. Louis County Water Co., University City, Mo.

MOST water works men are at a disadvantage when confronted with the problem of determining the reasons for a pipe failure. Few, if any, make a careful analysis of each failure, because the major concern is the rapidity with which repairs can be effected and the line returned to service. Perhaps the reason behind this apparent lack of interest in making a determination of the causes of failures is that it is somewhat analogous to locking the barn door after the horse has been stolen: the pipe has been laid, the mistakes have been made, some failures are unavoidable, and rapid repair and return of the line to service in the least possible time is the best that can be done under the circumstances.

The AWWA is performing an invaluable service in the attempt to determine the reasons for pipe failures. A task group has been activated with a directive to study breaks in water distribution systems. The AWWA has also been responsible for excellent specifications that cover the manufacture of various types of pipeline material and the installation of cast-iron pipe. Very few failures would happen if proper selection of material were made, and if pipelines were laid in strict accordance with specifications—the AWWA's for cast-iron pipe or the manufacturer's for other types.

Thomas F. Wolfe's excellent paper on the prevention of breaks in cast-iron pipe (1) is recommended reading for anyone interested in the subject. The paper attempted to determine the cause of pipeline failures through a survey in eighteen Illinois and Wisconsin cities with populations of less than 100,000. There were 2,034 miles of pipe in the systems covered by this survey. During the most favorable year, although not necessarily the best for a specific utility, the total number of breaks was sixteen. In the least favorable year, 55 breaks occurred. The total of all breaks occurring during the period of the survey indicated that the major cause (46 per cent) was faulty construction or interference by other underground construction. No reason was given for 29 per cent of the breaks. Other causes were: excessive pressure, 9 per cent; corrosion, 8 per cent; excessive load, 4 per cent; and faulty pipe, 4 per cent. This survey shows that there is a need for some standard method of analyzing and reporting pipeline failures. One of the jobs confronting the task group is the formulation of such a standard in order that data secured may be used to furnish understandable statistics.

The Indianapolis Water Co. made an analysis of pipeline failures occurring in 1926–54 (see p. 460 in this issue). It is quite difficult to correlate these

data with those in Wolfe's survey. The description of the causes of failures in some instances are entirely different, even though similar factors were involved.

Material Selection

The present-day water works operator has a distinct advantage over his predecessors in the selection of materials for transmission and distribution pipeline systems. A larger variety of well designed material is now readily available at competitive prices. It is the operator's duty and responsibility to exercise care in material selection for a particular environmental condition. For example, it would be a poor choice on the part of the operator to select a thin-wall steel pipe for use in a corrosive environment unless sufficient precautions were taken. It might also be a bad choice to select cast-iron pipe for the same type of environment. With severe water hammer conditions present, it might be an inferior choice to select any type of pipe unless proper water hammer control equipment were also installed. Some pipes have better characteristics for resisting beam and cantilever stresses than do others. The designer or person charged with the responsibility for selecting materials should take these and other factors into consideration when choosing a certain type of pipe for a particular application.

Manufacture

The four types of pipeline material now in common use for transmission and distribution systems are cast iron, steel, asbestos-cement, and concrete (either nonprestressed, prestressed, or prestressed cylinder type). The AWWA, in cooperation with the manufacturers of these products, has done a good job of writing specifications which insure the final user of a superior product. In cast iron, the design is predicated on research performed at the Iowa State College. The design is conservative, being based upon working pressure, water hammer allowance, and earth loads, plus a safety factor of more than 2½, with supplemental allowance for corrosion and factory tolerance. In 6-in., Class 150 cast-iron pipe, the specifications result in a pipe that will withstand an internal pressure of approximately 2,200 psi. The specifications insure material control, and each individual pipe must be tested at the foundry to either 400 or 500 psi, depending upon size and metal thickness. Other types of pipe are also conservatively designed, with adequate precaution against manufacturing defects by virtue of adequate material control and testing procedure. Because the manufacturing process is so well controlled by specifications, material testing, and pressure tests, it is unusual to find a pipeline failure caused by deficiencies in production.

Handling

Damage to pipe before installation can be, and often is, the cause of failures. Rough handling at the point of manufacture, by the carrier, in transit from the carrier to the job site, and by the force making the installation often results in irreparable damage to the material. Hairline cracks can be caused by the bumping of one pipe against another, or by the dropping of a pipe on a hard object, and these cracks cannot always be discerned by the so-called hammer test. This is particularly true in cast-iron pipe having a cement lining.

The St. Louis County Water Co. has had many breaks on newly laid pipe-

lines where there have been no apparent causes for the failure other than an incipient hairline crack. It is characteristic of these breaks that the split traverses the pipe longitudinally from the spigot end to the bell section. Often the split progresses into the bell. At other times, the pipe splits from end to end with a section at any point in the pipe being blown away from it. This type of break sometimes occurs when the pipe is resting on a hard object. In most of these cases, however, the pipe fails by beam action which results in a transverse break somewhat similar to the way a match would break if bent between the fingers. Some large-diameter pipes, in service for many years, have failed with a split extending from the spigot end to the bell. Careful inspection revealed no installation condition that could be responsible. Examination of the ruptured metal often revealed rust spots in the vicinity of the spigot end and bright metal elsewhere along the split. One conclusion that can be drawn is that the original pipe suffered a fine hairline crack in the spigot end at or before the time of installation and that ability of the pipe to resist internal pressures during the period of usage was due only to the fact that the spigot was restrained by the jointing material in the bell of the adjacent pipe. It is prudent for operators to take all means to insure that the various types of pipe are handled with the utmost care prior to installation if failure-free service is to be enjoyed afterwards.

Installation

Most failures in pipeline systems are caused by faulty installation, as indicated in the Wolfe survey and the Indianapolis Water Co. analysis. Pipes are not designed to act as beams, yet they are often installed in trenches so that beam action stresses are superimposed upon other normal stresses. A 6-in. cast-iron pipe, 18 ft long, is a very uneconomical beam section. A standard beam for an 18-ft span, with a normal uniform load, would have a depth of about 9–10 in. if deflection standards were not exceeded. Beams are generally designed to have the greatest mass of metal at the farthest point from the neutral axis. A pipe is a very inefficient section compared to an I-beam when used for resisting stresses induced by beam action.

Generally, a break caused by beam action stress is a transverse break. The metal is open more at the top than at the bottom if the pipe is acting as a cantilever, or the reverse if the pipe is acting as a simple beam. There may or may not be displacement of one end relative to the other in breaks of this kind. Failures of this type can be prevented by following the AWWA specifications for laying cast-iron pipe.

Trench Conditions

Trenching, blocking, and backfill conditions are important factors in increasing or reducing stresses caused by beam action. Ring stresses caused by the use of blocks and the depth of cover are provided for in the ASA standard method for computing wall thickness. Beam action can be eliminated by proper laying processes.

Joints

Defective joints also are a major source of trouble in pipelines. This type of failure is easily controlled by the operator. The popularity of mechanical joints or rubber ring joints, such as those used on concrete, asbestos-cement, and cast-iron pipe, is rapidly reducing the number of joint

failures on newly laid pipelines. Those who prefer to use poured joints, either lead or sulfur cement, are doing so because of economic considerations, with the full realization that there will be some added expense for repairing defectively poured or calked joints.

Corrosion

Corrosion, although not always obvious, is very often the cause of failure. Pipes frequently fail in the early morning when pressures generally are at their highest. The increase, about 10–50 psi, is small in relationship to the ultimate bursting pressure of the pipe. At first glance it seems odd that pipes which have been hydrostatically tested to 500 psi and have given years of service should fail when the pressure is raised a small amount above normal. Often the burst pipe appears sound. Yet a closer inspection may reveal serious deterioration by bacterial action. In such cases the pipe retains its original shape although the iron has been converted into corrosion products, which, together with the original graphite, result in a pipe that appears sound. Surprisingly, although only a fraction of the original strength remains, the pipe is capable of carrying water under pressure for some time if not subjected to above-normal pressure differentials.

Environmental conditions favorable to the growth of sulfate-reducing bacteria, a factor in this type of corrosion, are: [1] neutral pH (about 7); [2] absence of oxygen; [3] a source of organic nutrients; and [4] a source of sulfates. Pipe subjected to such corrosion generally appears sound, with a dull black color and no evidence of pitting. It is possible, however, to make large indentations in the pipe with a sharp-pointed, hardened-steel tool. An obvious solution to this problem is the use of nonferrous materials, or, if ferrous materials are utilized, the provision of an adequate coating to prevent contact between the metal and the surrounding soil.

Other Factors

Other factors which cause pipeline failures include: [1] disturbances due to other underground construction; [2] temperature variation; [3] water hammer; [4] too large taps; [5] faulty service line connections; and [6] faulty thrust blocking.

Disturbances due to other underground construction. These are a major cause of pipeline failures and one of the most difficult to control. Although an important factor, such a disturbance is really an accident, and the mere mention of it should suffice for this discussion. Procedures of inspection or operation can be devised to minimize such accidents.

Temperature variation. Stresses caused by temperature changes are a more important factor than is generally thought. Such stresses acting alone are insufficient to cause failure but, when they are combined with other stresses induced by either beam or cantilever action, failures do occur. It may be safely postulated that the stresses induced by shrinkage due to temperature changes are minor. In the Midwest the temperature of a pipe prior to installation may be as high as 150°F, while the low temperature, after installation, would ordinarily be somewhat above freezing. This temperature differential of 118°F will result in a metal stress of approximately 9,000 psi if the ends are fully restrained. In view of present specifications regarding metal strength, this is a safe stress. It is obvious that the

maximum induced stress would be materially reduced by any joint movement.

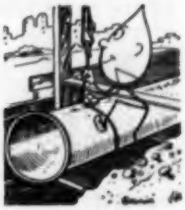
On the other hand, temperature stresses must be an important factor in pipeline failures. This element is necessary to explain the large number of failures which generally occur in the late fall or early winter. During this period the St. Louis County Water Co., in the operation of a system comprising about 1,400 miles of pipe, most of which is 6-in., 8-in., and 12-in. diameter cast iron, routinely anticipates a large number of cast-iron pipe failures. Generally, these pipelines have given years of trouble-free service. It is believed that stresses induced by temperature, combined with those due to beam action, are the primary cause.

Water hammer. This factor in pipeline breaks can be minimized by proper design and operating procedures. It is obvious there will be failures if water hammer surges of two to six times the operating pressure are allowed to occur. Quick closure of valves on any size pipeline should be avoided. Surges, due to power failures on transmission lines, can be limited by the installation of properly designed surge suppression equipment. Although troublesome, surges can be easily controlled.

The other causes previously mentioned—too large taps, faulty service line connections, and faulty thrust blocking—are well within the control of the utility operator. Diligence and carefulness on his part in making pipeline installations should minimize failures caused by these factors.

Reference

1. WOLFE, T. F. How to Prevent Breaks in Cast-Iron Pipe. *Jour. AWWA*, **38**:765 (Jun. 1946).



Problems of Small Water Systems in Maryland

Holmes Orgain

A paper presented on Oct. 28, 1954, at the Chesapeake Section Meeting, Baltimore, Md., by Holmes Orgain, San. Engr., State Board of Health, Baltimore, Md.

IN Maryland, the State Board of Health, specifically the Div. of San. Eng., has been vested with the responsibility of inspecting and regulating operation of public water supplies. The tendency toward decentralization, together with the housing shortage, has prompted construction of a large number of outlying projects, many of which have a central water supply system. These installations vary in size from those consisting of one well and pressure tank to plants providing complete treatment and adequate storage and distribution systems. The areas served vary from a few homes to communities of several hundred houses. This paper deals with the small water supply, whose problems of operation are many and varied. Recently, the Federal Housing and the Veterans Administrations have been instrumental in helping to develop satisfactory water supplies for housing projects. The two agencies do this by withholding property loans until the supply has the approval of the State Board of Health.

The number of public water supplies in Maryland fluctuates slightly from year to year as additional supplies are developed and existing ones are reduced by incorporation with those of towns or sanitary districts. The total number, year after year, seems to remain at approximately 200. By actual count, there were 197 at the end of 1953. Of this number, 79, or 40 per cent, failed to meet generally accepted standards for drinking water. These substandard supplies, however, serve only 2.2 per cent of the state's population. Although, numerically speaking, relatively few people are affected by these water supplies, a tremendous job remains to be done before all will consistently produce a water of satisfactory quality for it is more difficult to get deficiencies corrected in a small community than in one having considerable population.

Financing and Management

In 1953 inspection of a small water supply revealed that the source, a small mountain stream, was being polluted by nearby coal-mining operations. A study of the problem indicated that the stream could no longer serve as a source of water unless extensive treatment was employed. The system served only about 25 residences, so treatment of the surface supply was not economically feasible. The Div. of San. Eng., therefore, recommended that a source of ground water be investigated. Engineers of the health department contacted the State Dept. of Geology, Mines, and Water Resources

to obtain any information available on the practicability of developing a well. Men who were experienced in well-drilling operations in the area were also queried about the probability of obtaining water in sufficient quantities without drilling to excessive depths. The area of the community is honeycombed with coal mines, mostly abandoned. Water taken from an old mine working usually results in a supply which is extremely aggressive.

The people of the community felt that the coal mine operators should pay the full cost of a well and pumping equipment. The operators, realizing that they had a responsibility, agreed to pay a share of the cost. No agreement could be reached in spite of the fact that representatives of the Div. of San. Eng., the Bureau of Mines, and even the Asst. State Attorney attended numerous meetings in an attempt to reach a satisfactory settlement. Residents of the community have proceeded to drill and equip a well, and have employed an attorney in the hope that the cost can be recovered from the coal mine administrators. Located in the same general area as this small supply is a filtration plant serving about 50,000. Even though many thousands of dollars have been spent enlarging and improving facilities at the filtration plant, inspections of construction work in progress have required less time than has been spent at the smaller installation. Neither of these projects is yet complete. It appears that much more time is required to reach a satisfactory solution of the problems at small plants than at large ones.

Lack of money is always an issue when improvements are to be made to a public supply system. For the small water supply no money was available to drill a well and to purchase pumping equipment. During one of the town meetings, it was brought out that many of the residents connected to the supply did not pay the customary charge. Exactly why this was so, no one seemed to know. In fact, one of the members of the water committee made the statement that he had not paid his bills for the past 4 months. The committee had previously voted to supply all residents over 65 with water free of charge. The total amount of money received for water services was barely adequate to pay current expenses, with nothing left over for repairs or improvements. The lack of efficient financial management in small public water supplies presents a problem to a community when funds are needed.

Absence of Management

The author has had the occasion to deal with small public supplies in Maryland which had no management at all. In fact one system called to the attention of the division by a county sanitarian had no owner at all. The developer of a housing project of about 30 houses had installed a works consisting of two wells, pressure tanks, and a distribution system. Unknown to the health department, the supply had been operated for several years before the first inspection was made. After talking with some of the local residents, none of whom had any authority or were responsible for operation of the water facilities, it was learned that the original developer had sold all the properties to individuals, and had also included in the property deeds the right to use the water supply.

One resident, at the request of the health department, called a meeting of the property owners for the purpose of organizing a corporation or company

to form a legal body to purchase and assume responsibility for operation of the supply. The meeting was held in the home of the man who had made the arrangements, and only those people living in the upper half of the one-street community appeared. It was later learned that the community was divided into two factions. People living on one end of the street were not in complete agreement, on how a water system should be operated, with those living on the other end. The system had a well located at each end of the street, and the one-pipe distribution system was divided at the center point by a closed valve. Although it was recommended that one corporation be formed to acquire the facilities and operate both wells to supply water to the entire community, it was soon seen that no such proposal would work. The installation continued to be operated as two separate systems, each group collecting revenue for services and making repairs to that portion of the system supplying it with water. No one was responsible, nor did anyone have authority to make improvements. The wells, pressure tanks, and pumping equipment were in a deplorable condition, and the results of bacteriological sampling showed the water to be grossly polluted.

The health board issued an order on the original developer, because it was learned that he had retained legal title to the plots of ground on which the wells were located. The developer and his attorney visited the health department to notify it that in his opinion the developer had no legal or moral obligations about the water supply. Nevertheless, arrangements were made to transfer the legal title of the wells to the property owners. In order to do this, two separate companies had to be organized. After they had been formed and title to the supply facilities transferred, the health department was able to get representatives of each company to install chlorinating equipment. Although these supplies now have legal owners, numerous operating problems have developed. Hypochlorinators purchased to be used with the water systems were designed to operate on a 30-psi differential pressure. The pumps could not create the pressure differential required and still deliver sufficient water to meet the demand. A booster pump has since been installed to operate with one of the chlorinators. Disinfection of the other supply is sporadic and unsatisfactory; bacteriological samples are periodically collected from the system. The two supplies are being operated by residents of the community whose main interests are their regular jobs which furnish a livelihood. Thus, the operation of the system is incidental to other interests.

Operation of small public supplies seems always to be a major problem. Even though adequate facilities are provided, many times a water of inferior quality is distributed because of inefficient plant operation. This is particularly true for the operation of hypochlorinating units. Most small-plant operators are employed on a part-time basis, often receiving no pay for their efforts, and do not do a thorough job of operation and maintenance. Should mixing of a hypochlorite solution for the public supply interfere with other plans or necessitate going out in bad weather, preparation of the solution is usually deferred until a more opportune time. At one installation, the town mayor is responsible for operating the well pump and hypochlorinator. Although the health department

was instrumental in getting the mayor and council to install the chlorinator on the supply, efforts of the division have been unsuccessful in keeping it in operation. Positive bacteriological samples were being received regularly, and frequent investigations by personnel of the division showed that chlorinating equipment was not being properly operated. Sometimes the solution crock was dry, on other occasions the town was without calcium hypochlorite. Once, the solution crock was broken and the chlorinator was not in operation until another could be secured, several weeks later. At one time, the chlorinator and well pump were not serviced for a prolonged period due to illness in the mayor's family. There are numerous reasons why small plants are not properly operated, but the main reason why many are grossly neglected is that persons responsible for operation and maintenance received little or no compensation for their services.

Cross Connections and Drought

Another type of small-supply operating problem, from a public health standpoint, is the existence of cross connections between the community supply and privately owned installations. Although cross connections are sometimes found in any water system, the most numerous seem to occur in shore properties where the community system is operated only during the summer. More and more people are using waterfront sites or shore properties as year-round residences, and have developed privately owned wells (usually shallow in depth) to furnish water during periods when the community system is not in operation. The house distribution system alone forms a cross connection between the two supplies. On more than one occasion, as many as 20 privately owned wells have been found to be cross connected with the public system. Many privately owned wells are still being used to augment or substitute for the public water supply, but an earnest effort has been made to sever the cross connections, or replace them with approved couplings.

Although the public health engineer is primarily interested in quality, quantity sometimes plays an important part in the creation of health hazards and other serious problems. During the extended dry spell which began in June 1953 in central, southern, and eastern Maryland, many small supplies had to provide for additional water to augment the usual sources. In one instance the shortage became so acute that it was necessary to use emergency Federal Civil Defense Administration (FCDA) engineering equipment to treat water obtained from a different location. In another community, water had to be hauled by tank trucks and pumped into the distribution system. Other small towns and communities with public systems had to obtain water from emergency sources or were forced to develop additional sources to complement the rapidly dwindling supply.

A sanitary engineer is faced with several problems when a town runs out of water. Because all normally water-carried wastes immediately accumulate to form a public health hazard, water for the community must be secured as soon as possible. At one municipality, water from a stream located approximately 1¼ miles from the periphery of the town distribution system was pumped, filtered, and transported through a temporary 8-in. main,

using FCDA emergency engineering equipment stockpiled for use during major disasters.

The water shortage was officially reported to the health department on Jul. 20, 1954, and emergency equipment was placed in operation on July 27. Although 7 days may seem to be a long time when an acute water shortage is in progress, actually the necessary approval to use FCDA emergency equipment was speedily and effectively executed. A modern emergency filtration plant, with a capacity of slightly less than 0.5 mgd, together with 7,750 ft of 8-in. transmission main, was assembled and placed in operation during the 1-week period. At the end of August, 5.8 mil gal had been treated and pumped into the town system. As much water as could be obtained from the usual sources of supply was also treated to help meet the requirements. A new filter plant, located on a larger stream, is now under construction and it is hoped that a similar acute shortage will not happen again.

This paper has mentioned only a few of the problems which a sanitary engineer encounters when dealing with small public water supplies. Although the difficulties are numerous, and many are without an immediate solution, improvements to these systems are gradually being accomplished.

Financing New Water Main Extensions in California

Philip F. Walsh

A paper presented on Oct. 27, 1954, at the California Section Meeting, Long Beach, Calif., by Philip F. Walsh, Chairman, California Committee on Subdivision and Main Extension Rules; Vice-Pres., Southern California Water Co., Los Angeles.

WATER main extensions for new areas have presented one of the most difficult financial problems the utilities of California have ever faced. This has been particularly true in the postwar years because of the huge influx of population into California and the great number of new subdivision developments. The chart, Fig. 1, shows the population of California for several decades and includes a forecast of 14,500,000 people in 1960. There will undoubtedly be a continuation of the construction of new homes until 1960 at an average rate at least equivalent to that of the preceding decade. The great majority of new homes obtain service from a publicly or privately owned water utility. Therefore, the unprecedented and continued growth of new residential construction is directly related to the water utilities' problem of financing new services, main extensions, and water production facilities. Generally speaking, there appears to be no indication in the trend of residential housing construction that would justify the conclusion that the water utilities' present problem of financing for new business will become less serious in the near future.

The California Section of AWWA recognized this problem, and in December 1953 the chairman appointed a committee of seven members to carry out an investigation. Meanwhile, the California Public Utilities Commission had received numerous inquiries about the revision of present water main extension rules from various utilities throughout the state.

Investigation on Rule Changes

On Oct. 20, 1953, the commission instituted Case 5501 for an investigation, on its own motion, into the reasonableness of water main extension rules then effective for water utilities under its jurisdiction and the development of such extension rules as seemed reasonable. The commission order instituting the investigation stated the purpose thus:

> . . . to determine whether the rules, regulations, contracts and practices, or any of them with respect to the extension of water mains by privately owned public utility water systems throughout the State, are unjust, unreasonable, discriminatory or preferential in any particular, and to determine the just, reasonable and proper rules, regulations, contracts and practices, or any of them, applicable to said water main extensions, and to fix the same by order. . . .

A letter from the commission in November 1953, addressed to all pri-

vately owned public water utilities and other interested groups, stated, in part:

To consolidate these applications for hearing, to review the present main extension practices of all water utilities under this Commission's jurisdiction, and to determine the extent of modifications that may be warranted to conform to present economic conditions and other factors, the Commission has ordered an investigation of these matters on a statewide basis under Case 5501.

It is our understanding that many of the water utilities under this Commission's jurisdiction are willing to do much of the work required in developing both basic data and proposed changes in extension rules. . . .

In this way it is contemplated that all minor differences would be worked out at industry level, thus limiting the record before the Commission to proposals predicated upon materially divergent theories and policies.

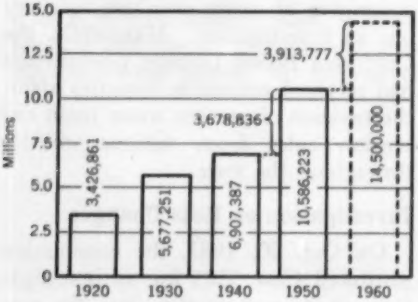


Fig. 1. Population of California by Decades

The 1920–50 figures were taken from the US Census Bureau. The 1960 estimate is the average of the US Census Bureau and California Dept. of Finance estimates.

Parallel hearings were held before the commission in San Francisco on Dec. 11, 1953, and in Los Angeles on Dec. 15, 1953. These hearings resulted in the formation of the California Committee on the Revision of Water Main Extension Rules and Regulations. Because the California Section committee had already been established, it served as the nucleus of the California committee. Members of the water utility industry and federal, state, and local authorities, as well as real estate and other organizations and individuals, were extended invitations to serve on the committee.

The California committee held a series of meetings both in San Francisco and in Los Angeles so that all those interested in the investigation would have a full opportunity to express their views and participate in the committee work. Public hearings were held before the commission at San Francisco and Los Angeles on eight separate days during the period Dec. 11, 1953–Jul. 12, 1954.

Main Extension Practices

An analysis of water main extension rules on file with the California Public Utilities Commission as of Jun. 30, 1953, pointed out that there was a wide divergence of rules among the regulated water utilities and an even wider divergence between privately owned utilities and publicly owned utilities. In general, the rules of the privately owned utilities provided that extensions to serve new individual customers were made at the company's expense when the total length of main extension did not exceed 100 (or, in some cases, 150) ft per service connection. If the free-footage allowance was exceeded, the applicant was required to advance the estimated cost of the excess, exclusive of the cost of the service connection, meter, or other facilities. The estimated cost of the extension had to

be computed on the basis of the cost of a main no larger than 4 in. in diameter, regardless of the size installed. The advance was subject to refund on the basis of the estimated cost of 100 ft or 150 ft of main extension for each additional customer directly connected to the extension. No interest was paid on the advance, and the agreement was in effect for a period of 10 years.

For most extensions to serve new subdivisions, the applicant advanced the cost of the distribution mains, exclusive of service connections, fire hydrants, and meters. Any additional water supply and pressure or storage facilities that might be required for the project had to be provided by the utility. The advance was usually subject to refund without interest, at the rate of 35 per cent of the gross revenue collected from all the customers directly connected to the extension. The agreement was in effect also for a period of 10 years. The publicly owned utilities usually required the applicant to pay the entire cost of the installation of the facilities, generally without refund, although in some cases an allowance was made. In addition, some publicly owned utilities required the applicant to pay a meter connection charge for each house.

Financing Extensions

E. F. McNaughton, the director of the public utilities department of the California commission ably stated (*1*) the problem thus:

> One of the outstanding rules, as to importance, relates to the basis of making extensions to serve new territory. This, of course, taps the fundamentals of the water works business while the service area is growing. Extension rules should be framed so as to encourage desirable new business, to add to and to build up the system, yet safeguard the main body of consumers by keeping out growth that is unprofitable and that otherwise would be a burden to the main system.

The committee set out, through a series of exhibits in Case 5501, to prove that the present main extension rules and regulations under which most of the privately owned utilities in the state were operating were inequitable to both the utility and its customers. In theory, the main extension rule was intended to obviate the possibility of placing an unfair burden upon existing customers through increased rates due to extensions that were not economically feasible, practical, or profitable.

In periods of abnormal growth, such as experienced throughout California since the end of World War II, the combination of inflated construction costs and inequitable extension rules had forced the utility to make investments considerably over the average for existing customers. An analysis of the total gross depreciable fixed capital per customer as reported by thirteen utilities in their annual reports to the Public Utilities Commission for 1945–52, inclusive, indicated the average per customer in 1945 to be less than \$215, while in 1952 it was over \$265 (Fig. 2). A further analysis of ten utilities and their average gross distribution-main capital per customer for 1945–52, inclusive, showed that this investment was a little over \$95 per customer in 1945, and nearly \$125 in 1952 (Fig. 3). This increased capital investment made it necessary for the utility constantly to seek new money and new rate structures in order to earn a fair return on the investment created by the addition of new customers. Because of the higher rates supporting the increased investment, a substantial burden was placed on existing customers.

The rules also seriously jeopardized the adequacy of service to all customers. The ratio of net revenue to gross revenue after direct expenses, depreciation, and taxes was such that the refund requirements for new subdivisions could not be developed from the revenues from new customers in the subdivisions. An analysis of the annual reports to the Public Utilities Commission made by fifteen utilities for 1950–52 showed that an average of 25 per cent of the gross revenue was left after all operating expenses, depreciation, and federal income taxes (Fig. 4). The extension rule provided that the refunds were to be made at a rate of 35 per cent of the gross revenue. Eleven of the fifteen utilities analyzed were below the average and only four were above.

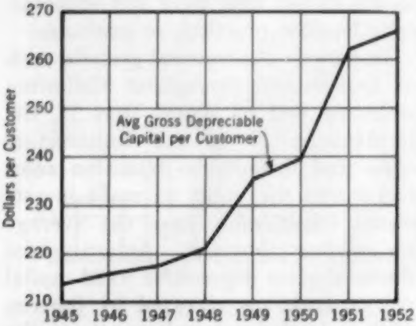


Fig. 2. Total Gross Depreciable Capital per Customer

The figures were reported by thirteen utilities except for the period 1945–47, when only twelve presented data.

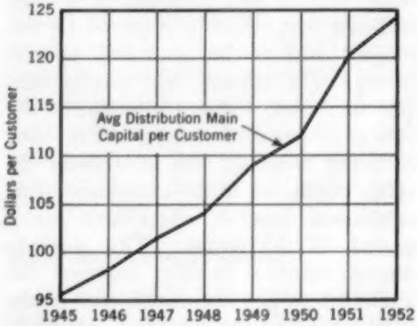


Fig. 3. Total Gross Distribution-Main Capital per Customer

The data were presented by ten utilities except during 1945–47, when only nine reported.

It was obviously necessary for the utility to secure new money to make part of the refund. This revenue had to be raised from one or more of the following sources: [1] new financing; [2] depreciation; [3] use of other consumers' advances; and [4] earned surplus. This imposed a severe problem on the smaller utilities because of their inability to effect new financing, owing to their unbalanced corporate structure. It was evident that a new extension should be self-supporting, insofar as refunds were concerned, to eliminate this part of the problem.

Committee Principles

The committee developed the following principles, which were acceptable to the majority, but which some members felt were not severe enough:

1. New extensions should not impose a burden upon existing customers through increased rates. Each extension should be self-supporting.

2. Applicants for extensions should advance the total cost of all facilities from the nearest existing main of adequate capacity. (The term "all facilities" includes distribution mains, services, fire hydrants, and any plant

or backup that is specifically required for service to the applicant.)

3. The same rule should apply to applicants for extensions whether in existing streets or in new subdivisions because the economic problem is the same to the utility. Refunds for both types of extensions should be made on the same basis.

4. Applicants for extensions should, by some method, advance the cost of the portion of new plant and backup which will ultimately be required to serve the new customers. This can be accomplished by limiting the refunds to a maximum amount so that there is an unpaid balance at the termination of the contract.

5. Refunds should in no case require new financing, but should be developed from the revenues from the new customers on the extension.

Suggested Extension Rules

In testimony before the commission, the committee submitted three basic extension rules in a series of four exhibits:

Fixed dollar refund method. The basic concept of this rule was limitation of investment. The rule:

1. Limited the allowance for refunds on extensions to the system average investment in distribution mains and services per consumer.

2. Assumed that distribution mains of 8-in. diameter and smaller were applicable to distribution. Mains larger than 8-in. diameter were assumed to have the dual purpose of transporting and distributing water.

3. Predicated refunds upon a uniform fixed dollar amount per consumer per month for a 10-year period or longer.

4. Required that, for new service connections, the applicant would have to pay the average current cost less the system average investment in services.

Cost to revenue principle. This rule assumed that the total investment in facilities could be related to the total annual revenue and expressed as a ratio, provided that the water system was earning a fair rate of return. Thus, the amount the utility can invest in main extensions bears approximately the same relationship to the anticipated revenue as the existing utility investment in mains bears to the revenue from existing customers. Under this limitation, the excess of revenue over that required for maintenance, operation, and fixed cost of the mains can be utilized to support the backup facilities serving or required to serve the new customer. The object of the rule was to limit the utility's investment in mains to an amount determined by the revenue to be derived from the new customer. Refunds were computed on the system average annual residential and commercial revenue per customer, or the estimated or guaranteed revenue.

Refunds based on percentage of revenue. This rule:

1. Limited the allowance or refund on extensions to the system average investment in distribution mains and services per customer. In no case would the utility be required to refund in excess of its ratio of investment in distribution mains and services to total depreciation capital.

2. Predicated the refunds upon the system average annual gross revenue per residential and commercial customer, or the estimated or guaranteed revenue.

3. Recommended certain limits for establishing refunds, consisting of 15–20 per cent of system average gross

revenue per residential and commercial customer, and a 10–15-year refund period, depending upon the situation of the individual utility.

Modified cost to revenue method. This rule:

1. Limited the allowance or refund on extensions to the system annual gross revenue related to the ratio of the system average investment in distribution mains and services to the system total average investment.

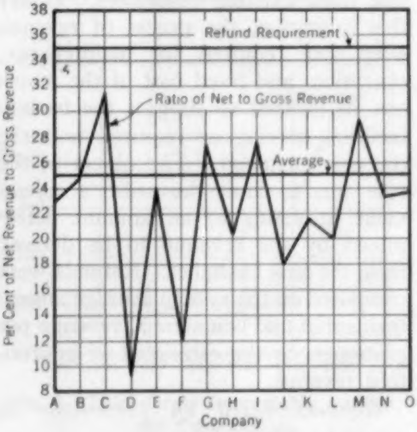


Fig. 4. Ratio of Net to Gross Revenue

The figures were reported by fifteen utilities. Net revenue is after expenses, depreciation, and taxes.

2. Predicated the annual refund rate upon the annual gross revenue from new customers, as related to the system net revenue factor.

3. Predicated the length of the refund period upon the total allowable refund divided by the annual refund rate.

Each of the rules submitted by the committee was prepared for the purpose of establishing a principle. Consequently, the rules were submitted in varying forms. The committee concluded it would be advisable to prepare an additional exhibit in which all the rules would be submitted in standard form using the same text and language wherever possible. This general text was prepared by the committee and subsequently submitted at a later hearing.

Commission Staff Exhibits

Following receipt of the committee's evidence, the commission staff presented its conclusions. The committee's principles, previously mentioned, were for the most part not acceptable to the commission staff, as indicated by the following summary of its conclusions:

1. Customer advances should not include cost of backup facilities unless agreed to by the parties and approved by the commission.

2. For general extensions, the utility should provide distribution mains free up to a specified distance, roughly equivalent to the average length of distribution mains per customer on its existing system.

3. The subdivider should advance the total estimated cost of the extension, as well as the cost of services if he elects to install them or their installation is required by public authority.

4. Refunds of the full amount advanced should be made if the extension develops a customer density comparable to that of the balance of the system.

5. In situations where the proportionate cost of refund works a hardship, the utility should be permitted to apply a percentage of revenue over a period not exceeding 20 years, subject, however, to termination of the agreement by mutual consent upon payment

of a lump sum if customer density on the extension approaches that on the balance of the system.

The commission staff also offered in evidence several suggested extension rules which the committee felt were not much of an improvement over the old rules. There followed a series of informal conferences between members of the commission staff and the committee in order to devise a rule which the commission would consider equitable to the public and the utilities, and which the committee members from the industry would regard as less burdensome than the present rule.

A rule meeting these conditions was finally worked out by the staff and the committee. Although the rule was not acceptable to some members of the committee, the majority agreed that, under it, most utilities could expand without becoming insolvent. This rule was offered into evidence.

Commission Decision

Having weighed all the evidence presented by the committee and commission staff, the commission handed down Decision 50580, issued its official order, and disposed of Case 5501. In the decision, under summary and conclusion, the following appears:

> There is no doubt in our minds, upon review of the record, that the privately owned water utilities in California need relief from the conditions imposed by the present rules relating to refunds of advances for main extensions. We, therefore, are of the opinion and we find as a fact that the existing rules and regulations relating to water main extensions maintained by the privately owned public utility water companies in California are unjust, unreasonable and insufficient, and that the water main extension rule [described below] set forth in Appendix B to the decision is and for the future will be the just, reasonable and sufficient rule respecting main extensions, to be observed by all such utilities. Should the prescription of said rule result in any increase in rates or charges, we hereby find that such increase is justified.

The order made it mandatory for all private utilities in California, within 40 days from the effective date of the order, to cancel existing regulations for the extension of water mains and to file with the commission the new form of rule as set forth in the order. The new rule became effective upon 5 days' notice to the commission and to the public.

Comparison of New and Old Rules

General provisions. The new rule includes a number of general provisions, all of which are very important to the utility in applying it. Briefly, the general provisions: [1] define a bona fide customer; [2] give the utility the right to design, locate, and construct the facilities to their specifications, with title to the facilities remaining in the hands of the utility; [3] adjust estimated costs to the actual costs upon completion of the installation; [4] refer disputes or disagreements in the application of the rule to the Public Utilities Commission for settlement; [5] include revenue from fire hydrant service in the computation of revenue refunds if the cost of the hydrants is incorporated in the advance; [6] do not require the utility to extend its service for fire hydrants or private fire protection; [7] define the method of estimating the annual revenue for refund purposes; [8] require grades to be established by public authority before the utility is enjoined to extend its facilities into a new area; [9] permit the utility to elect installa-

tion of a parallel main extension if the property to be served is located adjacent to a street or highway exceeding 70 ft in width, or a freeway, waterway, or railroad right-of-way; [10] allow estimated costs to be computed on facilities over 4-in. diameter which are to be installed in compliance with governmental regulations; and [11] give a formula for terminating refund contracts by lump sum payment.

Extensions to serve individuals. Under this section:

1. The utility is obliged to extend its facilities for bona fide customers at its own expense if the total length of main extension from the nearest existing distribution main is not more than 65 ft per service connection. The advance will not include the cost of service connections, meters, or increasing the size or capacity of existing mains or any other facilities used where necessary for supplying the extension. The estimate of cost for the advance shall not be based upon the cost of the main in excess of 4 in. in diameter, except where required by the special needs of the applicant. The advance is refunded by the utility without interest, in payments equal to the reasonable actual cost of 65 ft of main extension for each additional service connection, exclusive of that of any customer formerly served at the same location. Refunds must be made within 180 days after the date of the first service to the customer, and no refunds are made after a period of 10 years from date of completion of the main extension. The total refund shall in no case exceed the amount advanced.

The old extension rule required the utilities to extend 100 or 150 ft for each bona fide service connection. The refunds were predicated on the same footage, and the agreement was in effect for a period of 10 years.

2. Where a group of five or more applicants requests service on the same extension, or in other, unusual, cases where the commission approves, the utility may at its option require the applicants to advance the entire cost of the main extension, as provided for in the subdivision extension rule. Refunds may be made by a percentage of revenue method rather than by a proportionate-cost method.

3. Refunds must be given to the applicants making an advance where bona fide customers are served by a subsequent main extension, either continuous or lateral, supplied from the original extension upon which an advance is still refundable, whenever the length of such further extension is less than 65 ft per service connection. (This section is a complete departure from the old rule.) These additional refunds are equal to the difference between the service connection and the length of each required subsequent extension, multiplied by the average cost per foot of the extension used as the basis for the determination of the amount advanced. Where subsequent customers are served through a series of such main extensions, refunds are made to the applicants in chronological order, beginning with the first extension in a series from the original point of supply, until the amount advanced by any applicant is fully repaid within a period of 10 years. If, however, the utility installs a main larger than that for which the cost is advanced (4 in.) to serve an individual or individuals, and a subsequent extension is supplied from such a main, the original ad-

vancers will not be entitled to the refund which might otherwise accrue from subsequent extensions.

Extensions to serve subdivisions, tracts, housing projects, industrial developments, or organized service districts. For service to one of these:

1. The applicant has to advance the utility the estimated reasonable cost of the installation of distribution mains from the nearest existing main at least equal in size to the main required to serve the development, including necessary service stubs. Also paid for in advance are all appurtenances and fire hydrants when requested by the applicant or required by public authority. If additional facilities are specifically required to provide pressure or storage exclusively for the service requested, the cost of such facilities may also be included in the advance after approval by the commission. The advance never includes the cost of meters. This section of the new rule, which is the crux of the problem to California utilities, is far less burdensome than the old rule. It had been previously provided that the utility could only require the applicant to advance the cost of distribution mains, exclusive of service lines, fire hydrants, pressure and storage facilities, or meters. It is important that the new rule allows the utility to extend from the nearest existing main at least equal in size to the main required to serve such development. Under the old rule if the utility had an inadequate main adjacent to the new subdivision, the advance was estimated from the nearest existing distribution main. This meant, of course, that in large-sized projects the utility was often called upon to back up to an adequate main at a considerable investment with its own money.

2. The advance is subject to refund by the utility, without interest, and at the utility's option, under the provisions of either of the following methods:

a. Proportionate-cost method. For each bona fide customer connected to the extension the utility must refund an amount in proportion to the ratio

TABLE 1

Economic Effect of New Extension Rule at Vista Acres

Installation Costs	Amount—$
Distribution mains*	34,294
Service connections†	14,042
Fire hydrants‡	5,574
Meters§	7,160
Total	61,070
Avg per lot‖	171

Revenue and Expense	Amount—$	
	Total	Per Customer#
Gross revenue	1,280,000	43.37
Direct expenses and local taxes	607,064	20.57
Depreciation expense	122,804	4.16
Total expenses	729,868	24.73
Net revenue	550,132	18.64
Federal income tax	215,870	7.31
Net revenue	334,262	11.33

* Cast iron: total footage, 11,747; average footage, 33.
† Copper pipes, [illegible]-in. diameter, total of 358.
‡ Standard 6 in., total of 17.
§ Size [illegible] in. by [illegible] in., total of 358.
‖ 358 lots.
\# Average number of customers, 29,511.

of 65 ft of main to the total footage of main in the extension for which the cost was advanced. That is, the utility installs 65 ft of pipe for each customer. The refund period is 10 years. In the old rule this free-footage allowance was either 100 or 150 ft, and the period of refund was also 10 years.

b. Percentage of revenue method. The utility must refund 22 per cent of the estimated annual revenue for each connection on the extension for which the advance was made. Refunds may be made at the election of the utility, either annually, semiannually, or quarterly for a period of 20 years. No interest is paid on the advance, and the refunds never exceed the original amount of the advance. Previously the old rule required the utility, under the percentage of revenue refund method, to refund 35 per cent of the actual gross revenue from each customer on the extension for a period of 10 years. This, of course, was a severe hardship on the utilities which had to supply new money from some source to meet the refund requirement (see Fig. 4).

TABLE 2

Comparison of Old and New Rule

Item	Old Rule $	Per Lot $	New Rule $	Per Lot $
Subdividers' advance	34,294	96.00	53,910	151.00
Utility's investment	26,776	75.00	7,160	20.00
Total	61,070	171.00	61,070	171.00
Cash position				
Total gross revenue	15,500		15,500	
Total expenses	11,500		11,500	
Net revenue	4,000		4,000	
Annual refund†	5,430		3,420	
Deficit	1,430			
Excess			580	

* Number of lots, 358, times $43.47.
† Time required to refund in full: old rule, 6.3 years; new rule, 15.8 years.

Effects of New Rules

To analyze and compare the economic effect of the new extension rule against the old, all the factors involved must be investigated. For the purpose of comparison, assume the utility is requested to extend its facilities into a new subdivision of 358 lots, as shown in Table 1. Table 2 compares the application of the old extension rule (35 per cent of the revenue refunded over 10 years) with the new extension rule (22 per cent of the revenue refunded over 20 years).

The first advantage to the utility is that the immediate investment is considerably less under the provisions of the new rule. The required utility investment of $26,776 under the old rule compares with an investment of $7,160 under the new. The lesser immediate investment by the utility results in a greater investment by the applicant. This would have been $34,294 under the old rule, whereas it is $53,910 under the new. The difference is the result of including service connections and fire hydrants, previously provided by the utilities, in the advance.

Assuming the gross revenue from the customers in the project is identical, because the new rule does not affect the earnings, the annual refund requirement under the old rule is $5,430 as against only $3,420 under the new. The utility is obviously in a better position under the new rule. In this particular project the old-rule annual refund requirement of $5,430 and a net revenue of $4,000 results in a deficit of $1,430. The utility would then have to raise this money from a new source in order to meet refund requirements. Under the provisions of the new rule, however, as the annual refund requirement is only $3,420, and $4,000 net revenue is available, the utility can meet the refund requirement and have an additional $580 net revenue.

The "slippage" factor (deadline on the rate of return) is illustrated by the fact that under the provisions of the old rule this particular advance would be refunded in 7 years, whereas under the new rule it is to be refunded in six-

teen years. Utility management has had to attempt in every way to slow down the slippage in rate of return, as well as hold down the need for rate increases. The new rule will tend to slow down the utility's need for rate increases because its original investments in facilities are less, and because of the lower percentage of refund requirements, the investments will come onto the capital books more slowly.

Lump Sum Settlement

The committee had sought a rule or rules which would limit the investment for new business by the utility to the average investment per consumer already in the system. In the committee's proposals this was accomplished for the most part by limiting the refunds to the subdivider to a maximum amount which never equaled the advance. The commission staff's conclusions, however, disagreed with this theory and stated that refunding provisions for main extensions should be predicated upon refunding the full amount of the advance to the individual or subdivider, if the extension develops to a customer density comparable to the balance of the system.

A special feature of the new rule approved by the commission provided for the termination, by mutual consent, of percentage of revenue refund contracts after 2 years. This would take place upon payment to individuals or subdividers of the present worth of an annuity of equal annual payments of the unpaid balance of the advance at 6 per cent interest, as of the termination date of the contract. The effect of such a provision is to make available to the utility a method of paying off the subdivider if the tract fills up rapidly and of getting the main extension out of the category of consumers' advances and into the company's rate base as a fixed asset. This important procedure results in charging a portion of the cost of an extension to the donation account, thus reducing the rate base and

TABLE 3

Present Value of Annuity at 6 Per Cent Interest

No. of Years	Present Value of \$1.00 per Annum* \$	Present Value as Per Cent†
1	0.943396	94.339600
2	1.833393	91.669650
3	2.673012	89.100400
4	3.465106	86.627650
5	4.212364	84.247280
6	4.917324	81.955400
7	5.582381	79.748300
8	6.209794	77.622425
9	6.801692	75.574356
10	7.360087	73.600870
11	7.886875	71.698864
12	8.383844	69.865367
13	8.852683	68.097562
14	9.294984	66.392743
15	9.712249	64.748327
16	10.105895	63.161844
17	10.477260	61.630941
18	10.827603	60.153350

* $A_n = \frac{1-(1+i)^{-n}}{i}$; A_n equals present value of \$1.00 per annum; i equals interest rate; n equals period of years.

† One hundred times column two divided by column one.

to some extent limiting the investment of a utility in new extensions, as proposed by the committee.

To carry out the analysis of the economic effect of the new rule, assume that in the project presented in Table 2 the following occurs: The subdivider advanced \$53,910, and 2 years after completion of the installation a total of \$5,130 has been refunded. The lump sum the utility would have to pay

to settle the agreement (18 years is the period of time remaining) with the subdivider would be calculated as follows:

Amount advanced	$53,910
Amount refunded to date	5,130
Balance due	$48,780

Equal annual payments of the unrefunded balance of $48,780 for 18 years would be:

$$\frac{\$48,780}{18} = \$2,710$$

The present worth of an annuity of $1.00 per year for 18 years computed at 6 per cent interest is 10.827603 (Table 3). Multiplying the annual payment by this annuity factor results in the total payment of:

$$10.827603 \times \$2,710 = \$29,343$$

The procedure may be simplified by the use of Table 3, which contains percentages to be applied to unrefunded amounts. The percentage in the case described could be computed as follows:

$$0.60153350 \times \$48,780 = \$29,343$$

The factor used was derived in the construction of the table by dividing the present worth of an annuity of $1.00, or 10.827603, by the remaining years of the agreement, or 18 years. The difference between the unrefunded amount and the lump sum payment to the subdivider would be accounted for in the utility's books as a donation:

Amount unrefunded	$48,780
Less payment to subdivider	29,343
To donations account	$19,437

Conclusion

No one would have the temerity to conclude the new extension rule is the answer to all the financial problems of utility extensions. Undoubtedly, problems will arise in the application of the new rule, which will, however, be considerably less burdensome to the regulated water utilities of California than the old rules, which have proved to be inequitable for all concerned except the applicant. The new rule will certainly have to be reviewed in several years to analyze the financial impact it has had on the water utilities operating under its provisions.

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Accelerating Calcium Carbonate Precipitation in Softening Plants

Robert F. McCauley and Rolf Eliassen

A contribution to the Journal by Robert F. McCauley, formerly Research Asst., Massachusetts Inst. of Technology, Cambridge, Mass. (now Assoc. Prof. of Civ. Eng., Michigan State College, East Lansing, Mich.), and Rolf Eliassen, Prof. of San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass.

RADIOACTIVE strontium presents one of the greatest problems among the radioisotopes which may find their ways into water supplies as a result of the use of nuclear weapons or nuclear power (*1*). Extensive studies on the removal of this element from contaminated waters have been conducted in the Sedgwick Labs. of Sanitary Science at Massachusetts Institute of Technology, Cambridge, Mass., under a contract with the US Atomic Energy Commission (No. AT(30-1)-621). Previous papers and reports (*2–5*) have presented some of the procedures and results of these studies.

Because strontium is an element which occupies a position in the periodic table of elements similar to calcium, the removal of strontium ions from water supplies could be accomplished by the processes utilized for calcium removal (*1*). Reduction of calcium hardness to a low level is imperative for a high degree of removal of strontium. The authors found that more basic information was needed on the mechanism of calcium carbonate precipitation in lime softening processes in order to assure maximum precipitation of strontium. This paper presents some of the results obtained in the calcium carbonate studies and establishes the background needed for an understanding of the paper in this issue (see p. 494) covering studies on the removal of radiostrontium from water supplies.

Reaction Rate

The precipitation of calcium carbonate in a water-softening process is a chemical reaction which does not proceed to equilibrium at a rapid rate. The importance of reaction time is demonstrated by Fig. 1, which shows the time-hardness relationship obtained when calcium carbonate was precipitated in five different chemical reactions. The treated waters were stirred throughout the entire period, and a constant-temperature water bath was used. These experiments showed that, after 5 min of reaction time, 325–380 ppm of hardness remained in each sample. This value decreased to 100 ppm or less within 80 min after the reacting chemical had been added, and to 30–50 ppm after about 3 hr of stirring. Thus, after 3 hr of reaction, the solutions had not reached the theoretical equilibrium value of about 15 ppm hardness. It was observed that the addition of calcium carbonate crystals, or other crystalline material, combined with rapid stirring, accelerated the reaction to a marked degree. The

addition of 5 per cent of preformed crystals to the waters after a 3-hr reaction time, together with rapid stirring, reduced the hardness to the theoretical value within 5 min.

hardness, and noting, at the same, the changes in pH. Figure 1 indicates that, when no preformed crystals were present, a wide variation was to be found between the titration curve and

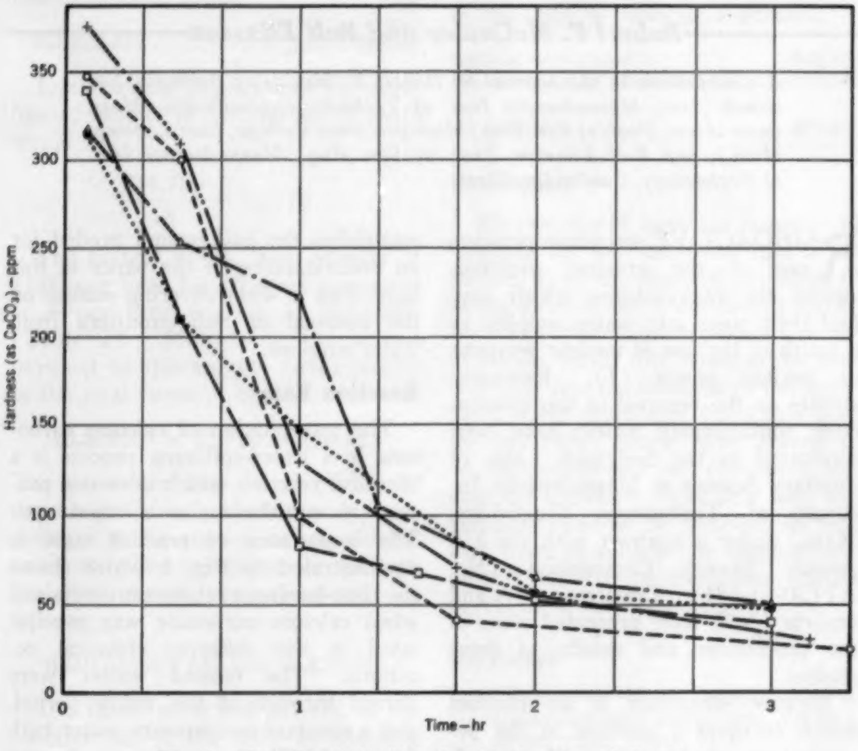

Fig. 1. Time-Hardness Relationship in Lime Softening

○—$Ca(HCO_3)_2$ in solution, $Ca(OH)_2$ added; +—$Ca(HCO_3)_2$ plus 700 ppm NaCl in solution, $Ca(OH)_2$ added; △—$CaCl_2$ in solution, Na_2CO_3 added; □—$CaCl_2$ + $Na(HCO_3)$, NaOH added; ●—Na_2CO_3, $CaCl_2$ added. Various chemical reactions precipitate the $CaCO_3$.

A measure of the effect of the preformed crystals upon the reaction rate may be obtained from Fig. 2a and 2b by comparing the separation between the equilibrium condition curve to the curves obtained by adding lime to water containing calcium bicarbonate the equilibrium condition curve. With increasing percentages of preformed crystals, the after-1-min curve approached the equilibrium condition curve. Thus, the presence of 8 per cent of preformed crystals, by weight, accelerated the softening reaction to

such a degree that an equilibrium condition was approached during the first 1-min period when saturated lime water was being added, and an equilibrium state was reached during the 1-min period of rapid stirring.

Pilot Plant Studies

The practical significance of the results of the experiments described is strikingly illustrated by the data obtained from a small-scale pilot plant (see Fig. 3) designed to soften water under carefully controlled conditions. A reaction basin having an average retention time of 20 min was provided with a propeller mixing device. This was followed by a solids-contact process ("upflow") basin having a retention time of only 2 min at an overflow rate of 5 gpm per square foot. The short settling time and high overflow rate were made possible by the use of sizable quantities of rapidly settling crystals in the reaction tank. Calcium carbonate hardness was removed in the form of substantial growths of crystals rather than as a fine crystalline precipitate. The settling characteristics and accelerating action of the crystals permitted water to be softened to near equilibrium at almost any level of hardness desired. The effluent was remarkably clear.

An integral part of the softening plant was a pH meter which served as the control device for plant operation. Lime was fed to maintain the desired pH level and never on a concentration basis. It was necessary to analyze alkalinity and hardness only when the raw waters contained noncarbonate hardness. Determinations were then required to compute the soda ash required to soften to the theoretical limit.

The value of pH control of plant operation is shown in Fig. 1 by the relationship of pH to final effluent hardness. This curve was determined by operating the pilot plant at various pH levels while softening with lime a water which contained only calcium bicarbonate hardness. Preformed crystals were present to the extent of 3 per cent by weight. The pH level was adjusted to give the various points on the curve by increasing the lime concentration in the feed line. Under conditions approaching equilibrium it was possible to obtain an optimum removal of calcium hardness by feeding lime to maintain the pH level which plant experience had shown to be most satisfactory. This operational procedure was successful because the 20-min stirring period carried the lime–calcium bicarbonate reaction virtually to completion by the mass action effect of 3 per cent of preformed crystals.

When part of the calcium hardness was in the noncarbonate form, soda ash was required to obtain optimum calcium precipitation. The soda ash was added upon a concentration basis, as it could not be fed in terms of pH level. When soda ash was added in the necessary concentration, or in a slight excess, lime was fed to maintain the desired pH level. Effluent hardness again ranged from 15 to 25 ppm.

Discussion of Results

The results of these experiments on the mechanism of the lime-soda water softening process have indicated that the rate of the softening reaction may be accelerated in the presence of preformed calcium carbonate crystals and by using pH as the principal criterion of plant control. The reaction proceeds quickly to a state approximating equilibrium, yielding an extremely stable effluent without the necessity for long periods of mixing and flocculation.

When a water is lime-soda softened in the presence of copious quantities of calcium carbonate crystals, a relationship may be established between residual calcium hardness and pH level. If the requisite concentration of soda ash is added to react with noncarbonate hardness, a value of 15–25 ppm of calcium hardness should be obtained easily. This is accomplished by reacting the raw water with lime and soda ash and stirring rapidly in the presence of 3–5 per cent preformed calcium carbonate crystals at a pH of about 9.8–10.2. Under such circumstances about 20 min is required to cause the chemical reaction to reach a state close to equilibrium. Shorter reaction periods may be used with higher concentrations of preformed crystals. This suggests that the methods mentioned are directly applicable to the softening of waters containing 60 ppm or less of magnesium hardness. Some magnesium removal may then be noted and calcium hardness may be reduced to a level of 25 ppm or less, to provide an effluent hardness of 85 ppm or lower.

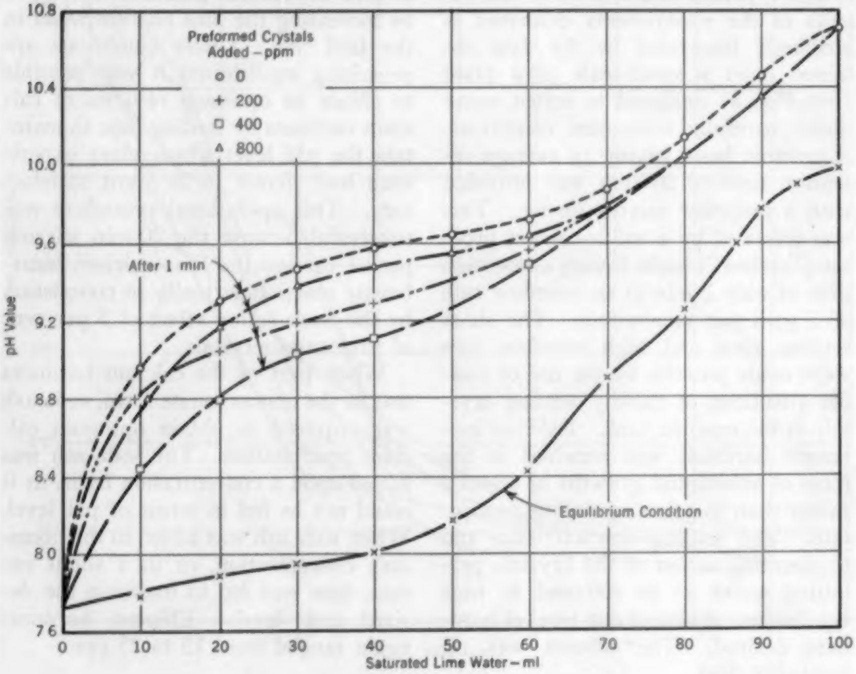

Fig. 2a. Effect of Preformed Crystals

Water containing calcium bicarbonate is titrated at 25°C with lime water. (Compare Fig. 2b.)

These procedures are applicable to both upflow and conventional plants. No change in upflow plants is necessary. In conventional lime-soda plants with separate coagulation and settling

tanks, provision must be made for 5–20 min of thorough mixing with 3 per cent or more of preformed crystals by returning sludge from the settling tanks. The basic suggestion here is that the pH meter is the proper instrument for plant control when preformed crystals are added to the mixing basin in such concentration as to cause softening to proceed quickly to completion. If lime feed is controlled directly in terms of the desired pH level, the feeding of an almost exactly chemically equivalent quantity will result.

Many plants control operations by setting chemical feeders to dose the water with a predetermined quantity of lime, based on chemical analyses of the raw water. Thus, quantity of lime rather than pH is the criterion of control. This leaves no direct measure of undertreatment or overtreatment and does not provide for a determination of the rate of the softening reaction in the plant. Further, the degree to which the reaction has proceeded at various points in the plant is not readily observed. With a limited time in the mixing, coagulation, and settling basins or compartments, the rate of reaction becomes all-important. Plant control by pH measurement and return of preformed calcium carbonate crystals to the influent will assure rapid

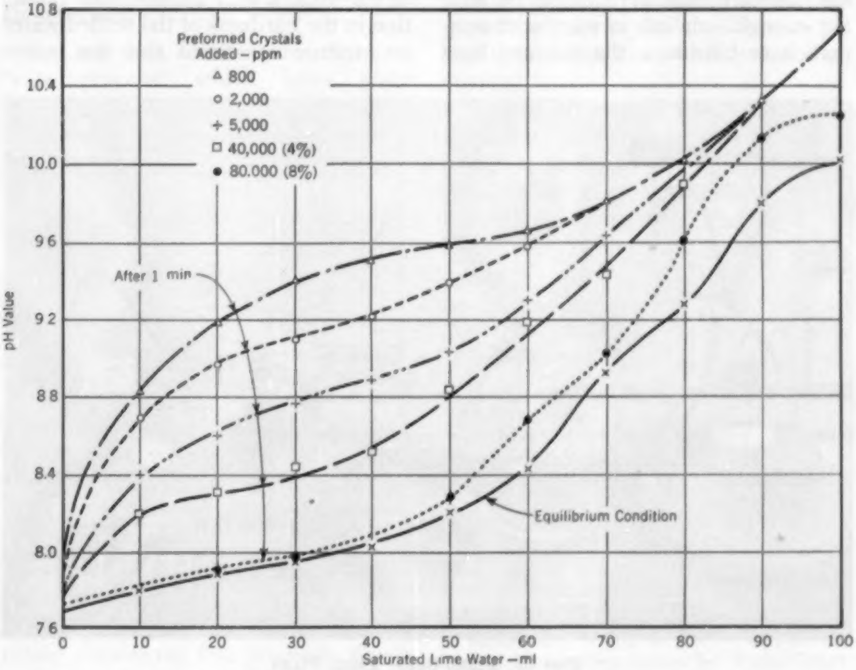

Fig. 2b. Effect of Preformed Crystals

Water containing calcium bicarbonate is titrated at 25°C with lime water. (Compare Fig. 2a.)

rates of reaction and the lowest possible hardness of the effluent.

When waters contain more than 60 ppm of magnesium hardness, excess-lime treatment is required to remove magnesium hydroxide at a pH of 10.5 or higher. If this reaction is made to take place in the presence of preformed calcium carbonate crystals, while adding enough soda ash to react with noncarbonate hardness, the calcium level of the water should be 30–50 ppm (as $CaCO_3$), and the total hardness 40–80 ppm.

If this treated water is settled, the pH may then be lowered by the addition of CO_2 (recarbonation) or by mixing with raw water (split treatment). Particles of magnesium hydroxide carried over from the settling basin may tend to redissolve because of lowered pH and thus increase the hardness. If recarbonation or split treatment is carried out in the presence of preformed crystals, however, the decrease in calcium hardness will be greater than the increase in magnesium hardness. When recarbonation or split treatment is carried out at a pH level of 9.8–10.2, a very considerable reduction in the hardness of the settled water or mixture of settled and raw water will be noted. Such reduction in hardness may be large enough to permit the feeding of soda ash to be greatly reduced, or even abandoned entirely, with a considerable saving in cost of chemicals.

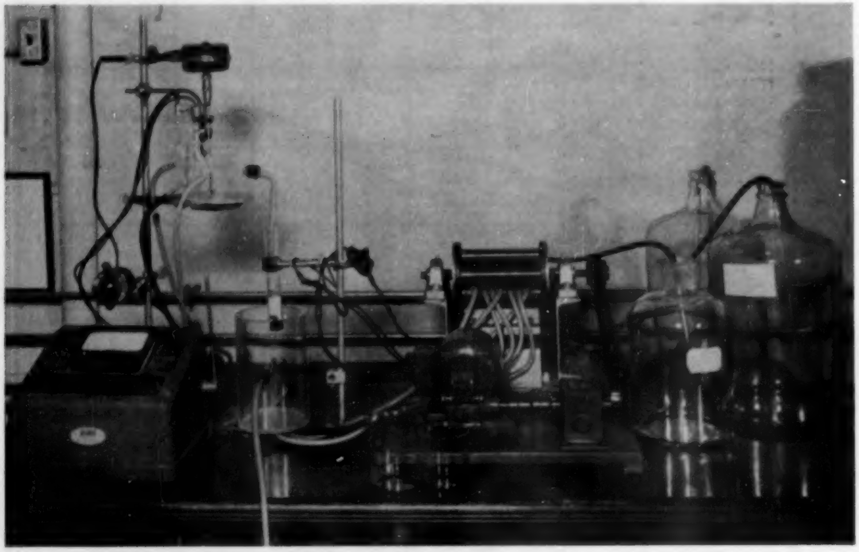

Fig. 3. Small-Scale Pilot Plant

Small amounts of water are softened under carefully controlled conditions.

Sand filtration of water which has undergone recarbonation or split treatment causes calcium carbonate growth upon the sand grains unless the water

is stabilized before filtration. The authors have shown on a pilot plant scale (*5*) that this stabilization may be accomplished by stirring the water with preformed crystals in the manner just described in order to drive the reaction between unreacted lime and CO_2 or raw water to completion.

Conclusions

1. Lime-soda softening reaction is a "rate process" which takes place quickly at high concentrations of reacting substances but proceeds slowly as the reaction approaches equilibrium.

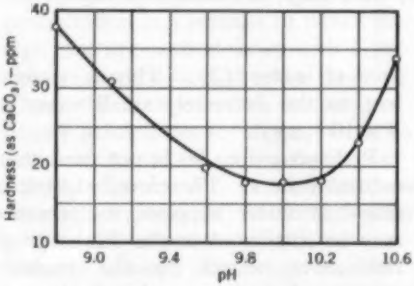

Fig. 4. Effect of pH on Effluent Hardness

A pilot plant was operated at various pH levels. Raw water hardness was 120 ppm (as $CaCO_3$); reaction time was 20 min; and preformed crystals were 3 per cent by weight.

2. Rapid mixing with preformed crystals accelerates the reaction. This effect explains the value of solids-contact units.

3. When a water containing only calcium bicarbonate hardness is softened with lime in the presence of enough preformed crystals to approximate equilibrium conditions, a relationship can be shown between calcium hardness and pH level. If calcium noncarbonate hardness is present, the same relationship can be obtained by adding soda ash in a chemically equivalent quantity which will react with the noncarbonate hardness.

4. Lime-soda removal of calcium in the presence of preformed calcium carbonate crystals occurs through the growth of the crystals. These settle rapidly and produce an effluent of high quality.

5. Stirring treated waters with preformed crystals is of value in producing a stable, low-calcium water after recarbonation or split treatment.

6. A minimum calcium level of 15–25 ppm (as $CaCO_3$) can be obtained by stirring lime-soda softened or recarbonated water with copious quantities of calcium carbonate crystals at an equilibrium pH of about 9.8–10.2.

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Radioactive-Strontium Removal by Lime-Soda Softening

Robert F. McCauley and Rolf Eliassen

A contribution to the Journal by Robert F. McCauley, formerly Research Asst., Massachusetts Inst. of Technology, Cambridge, Mass. (now Assoc. Prof. of Civ. Eng., Michigan State College, East Lansing, Mich.), and Rolf Eliassen, Prof. of San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass.

As indicated in the preceding paper in this issue (see p. 487), the mechanism of removal of strontium from waters contaminated by radioactive nuclear-fission products is similar in principle to the removal of calcium from hard waters. The first phase of the research project for the US Atomic Energy Commission established the most feasible means of accelerating the precipitation of calcium to values approximating equilibrium conditions in lime-soda softening processes. The second phase of the studies sought to adapt these means to the removal of strontium.

Radiostrontium

Radioactive strontium 90 (Sr^{90}) was used in these studies. As its half-life of 25 years is the longest of the eight known radioisotopes of strontium, it is most likely to cause maximum long-term damage to human tissues. Medical evidence shows that it is readily absorbed in bones and can thus affect the functioning of the bone marrow (*1*). The National Committee on Radiation Protection has established the maximum permissible concentration of Sr^{90}—in equilibrium with yttrium 90 (Y^{90})—as 8×10^{-4} microcuries per liter of water (*2*). This is equivalent to the extremely small value of 5×10^{-8} mg/l.

Radiostrontium 90 is not present in natural waters. Therefore, when it is found in water supplies, its presence may be attributed to the discharge of radioactive wastes by the nuclear-power industry or nuclear-fuel processing establishments, or to fallout from nuclear-weapons tests by the United States, Great Britain, or the USSR. Radioactive fallout circles the globe many times in the upper atmosphere, and has come down in many parts of the world with rainfall. Although some concentrations of Sr^{90} have been found in public water supplies, no observations of values near the tolerance level have been reported. With the increasing activity of the nuclear-fission industry, it is essential that the water works profession be prepared to handle radiostrontium and other radioactive isotopes which cannot be destroyed by any known process. These substances must be taken out of the wastes at the source or removed in water treatment processes.

Many water treatment plants are equipped with facilities for mixing, coagulation, and sedimentation, and the

removal of strontium with calcium by a lime or lime-soda treatment process might hold promise of success. Plants using alum or iron salts could be converted quite easily in an emergency to lime-soda, because the same flow scheme would be employed. Therefore, the authors subjected the precipitation of strontium with calcium to intensive fundamental and practical studies.

Precipitation of strontium with calcium is known as coprecipitation or carrier precipitation. In general, coprecipitation is a process in which foreign ions are carried down with a precipitate formed in a chemical reaction. Thus, the formation of calcium carbonate precipitates in water provides a practical means of concentrating extremely dilute solutions of hazardous radioactive elements as foreign ions within the crystals of calcium carbonate. Among the ways in which coprecipitation may be accomplished are: [1] the formation of mixed crystals where foreign ions are incorporated homogeneously in the crystal lattice; [2] the occlusion of impurities as imperfections scattered at random throughout the crystal; and [3] surface adsorption of foreign ions by the precipitate after it has already been formed (*4, 5*).

Crystal Formations

The studies to be reported in this paper have shown that radioactive strontium is removed in the lime-soda softening process by the first of the processes mentioned above—mixed-crystal formation. When two crystals have the property of associating in mixed crystals, they are said to be miscible. This is a true condition of solid solution, or the solution of one solid substance in another. Within the limits of solid solution, crystals are either miscible or nonmiscible. When a foreign ion forms mixed crystals with the ions of a precipitate, it will do so in any dilution which falls within the limits of solid solution (*5*).

X-ray studies by Vegard (*6*) have led to the formulation of the activity law which provides a reliable means of measuring the miscibility of crystal types. Vergard's law states: "In solid solution of two crystals of the same structure, the lattice constants vary linearly with the concentration of the solute." This means that the lattice constants of a crystal (which can be measured by X-ray diffraction) will change in direct relationship to the amount of foreign crystal present in mixed-crystal form.

When radioactive or stable isotopes of strontium are removed from water by coprecipitation in lime-soda softening, three different ions are involved: calcium, strontium, and carbonate. As each ion has its own ionic radius, the three may be likened to building blocks of different sizes.

In the formation of pure calcium carbonate, the crystals will be made up of equal numbers of two sizes of building blocks, calcium ions and carbonate ions. The dimensions of a unit crystal will then be its lattice constant in Ångstrom units. The lattice constants, when determined by modern X-ray diffraction methods, are measured to a degree of accuracy equal to that obtainable in weighing with the finest analytical balance and beyond that which can be obtained in measuring a building block with a steel rule.

If a mixed crystal of calcium carbonate and strontium carbonate is formed, some of the calcium ions, or calcium building blocks, are replaced by strontium ions. Strontium ions

have an ionic radius about 15 per cent larger than calcium ions. Because of this difference in size, the lattice constants of a crystal containing both calcium and strontium carbonate will be larger than that of one made up of pure calcium carbonate. Therefore, on the basis of Vegard's law, if calcium carbonate and strontium carbonate are miscible and form mixed crystals, the size of the crystal lattice should be di-

Fig. 1. Geiger Counter X-Ray Spectrometer

This machine was used for studies on crystal structures.

rectly and linearly related to the concentration of strontium in the crystal.

At least three anhydrous crystalline forms of calcium carbonate are known to be formed in lime-soda softening. Of these, calcite is the commonest and the most stable at ordinary temperatures. Another, aragonite, is only slightly less stable and, in water, tends to transform into calcite at an extremely slow rate. The third form, vaterite, is unstable and changes into aragonite or calcite unless promptly separated from the water and stored in a dry state. In cold lime-soda softening, calcite is the crystal commonly formed, although 10–15 per cent aragonite is often present. In hot lime-soda softening, aragonite is predominant. Under unusual conditions vaterite may be formed, but it soon changes to calcite.

Strontium carbonate exists in a single crystalline form, strontianite, found in nature. More commonly, mixed crystals of strontianite and aragonite are noted. Such observations strongly suggest that mixed crystals are formed when aragonite is precipitated in the presence of strontium (stable or radioactive).

In recent years Faivre (*7*), upon the basis of Vegard's law, has been able to demonstrate that aragonite and strontianite are miscible in all proportions. This proof was obtained by adding excess quantities of sodium carbonate (Na_2CO_3) to solutions containing varying percentages of strontium and calcium chloride. X-ray diffraction measurements of the lattice constants were then made and plotted against the strontium-calcium ratios of the solutions. These plots gave straight-line relationships which showed aragonite and strontianite to be completely miscible and to form mixed crystals in all proportions. These substances can form mixed crystals because the strontium ion is only about 15 per cent larger than the calcium ion and both crystals are of the orthorhombic crystal systems.

Calcite-Strontianite Crystals

Calcite is of the hexagonal crystal system—different, therefore, from aragonite and strontianite in this re-

spect. This variance does not preclude the formation of mixed crystals by calcite and strontianite, the two common crystal forms associated with cold lime-soda softening. On the contrary, a few small deposits of mixed calcite-strontianite crystals have been found in nature. Moreover, Faivre was also able to show that when mixed crystals of aragonite and strontianite were heated to 450°C, mixed crystals of calcite and strontianite could be formed, and that the solubility limit of strontium in calcite was 11 per cent. Faivre did not demonstrate that mixed crystals of calcite and strontianite could be produced by precipitating calcium carbonate in the presence of strontium. His difficulty probably lay in the relatively low solubility involved, the small changes in lattice constants, and the low degree of accuracy obtainable with X-ray equipment available in France during 1943.

Experiments were conducted by the authors in an effort to determine whether mixed crystals of calcite and strontianite could be obtained by precipitating calcite in the presence of strontium in lime-soda softening. Hard water was made up by adding 500 mg of calcium chloride (computed as $CaCO_3$) to six 2-liter portions of distilled water. Strontium chloride solution was then added to provide 1, 2, 3, 5, 8, and 10 ppm of strontium. The solutions were well mixed, and 330 ppm of sodium carbonate was added to each beaker and stirring continued for 30 min. The solutions were then filtered to separate the crystalline precipitates. These were subjected to X-ray diffraction measurement for the *D* spacing* of calcite crystals. The (2,000) plane was observed because for calcite it is stronger in intensity than any other by a factor of ten. The instrument used for these studies of crystal structure was the "Norelco"* Geiger counter X-ray spectrometer shown in Fig. 1.

The X-ray diffraction data are presented in Fig. 2, which shows a linear relationship between the *D* spacings and the strontium concentration in the solution in which the crystal was formed. Upon the basis of Vegard's law, the straight-line relationship may be considered proof of mixed calcite-strontianite crystal formation within the limits of solubility studied. In these experiments the maximum strontium-calcium ratio was one part of strontium to twenty parts of calcium.

Strontium Coprecipitation

Having proved that strontianite forms mixed crystals in lime-soda softening with both aragonite and calcite, it was possible to proceed with tracer studies on radioactive strontium. A radioactive solution was made up by adding 200 counts per second of Sr^{90}-Y^{90} activity to 4 ppm of stable strontium and 250 ppm of calcium chloride (computed as $CaCO_3$) in distilled water. Six 100-ml portions of the solution were then added to Erlenmeyer flasks and heated to boiling. Sodium carbonate (Na_2CO_3) was then added in amounts varying from 100 to 350 ppm (as $CaCO_3$). This procedure precipitated aragonite over a range of calcium-to-carbonate ratios varying from 0.71 to 2.5. Because of the boiling temperature, equilibrium was reached quickly and only a 5-min reaction time was required. Contents of the flasks were centrifuged at high speed. The clarified water was ana-

* *D* spacing is the distance in Ångstrom units between planes of atoms in a crystal formation.

* A trade name of the North American Phillips Co., Inc., New York.

lyzed with a Geiger counter for Sr^{90} activity. Residual calcium was determined by chemical analysis.

A second experiment was made to precipitate calcite under similar conditions, with the exception that 1,000 ppm of powdered calcite crystals was added to the solution and the reaction took place at room temperature. Calcite was precipitated by adding Na_2CO_3 in the same amounts as in the test for aragonite. The flasks were stoppered

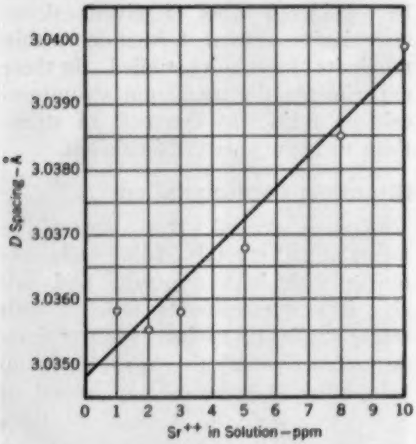

Fig. 2. Effect of Strontium on Calcite *D* Spacing

The accuracy of the measuring device was 0.0002 A. The D spacings are for the (2,000) plane.

and shaken. Addition of calcite crystals to the flasks assured that calcite, free of aragonite, would be precipitated. Also, the powdered calcite accelerated the reaction rate of the softening process so that a condition approximating equilibrium was reached within 1 hr of shaking time. The flask contents were centrifuged and the Sr^{90} and calcium contents of the clarified waters determined.

Figure 3 shows the relationship obtained between strontium removal and calcium removal. The curves show that aragonite crystals are more effective for removing strontium by coprecipitation than calcite is. A maximum removal of 96 per cent of radiostrontium was obtained by forming aragonite and by adding enough excess sodium carbonate (soda ash) to reduce the calcium hardness to about 8 ppm. With calcite, a removal of only 82 per cent was observed with an equal calcium reduction.

Studies were also conducted to determine the effect of the content of stable isotopes of strontium in water on the percentage removal of radiostrontium. The experiments were similar to those already described, with the exception that only two calcium-to-carbonate ratios were studied and the strontium content was varied from 0 to 10 ppm. The results of these experiments, presented in Table 1, show that, within the limits studied, strontium concentration had no effect upon the percentage removal of radioactive strontium. Such results point out the value of a relationship proposed by Kolthoff and Sandell (*3*) for conditions of solid solution at equilibrium. For the substances considered in Table 1 this relationship may be stated thus:

$$\frac{\text{Ca(precipitate)}}{\text{Ca(solution)}} = D \times \frac{\text{Sr(precipitate)}}{\text{Sr(solution)}}$$

D is a constant value, termed a "distribution coefficient." From the tests, it would appear that *D* for a calcite-strontianite relationship lies between 0.50 and 0.60.

If the reactions of softening (the precipitation of calcium carbonate) were instantaneous, the curves of Fig. 1 would be straight lines with slope *D*. Because of the time required for equi-

librium, however, more radiostrontium is removed when the last fraction of calcium hardness is precipitated than during the period of precipitation for the first calcium fraction. This factor of time required to reach equilibrium makes an accurate determination of *D* difficult.

More important is the effect of calcium removal on strontium removal. Table 1 shows that, for effective removal of strontium in lime-soda softening, it is imperative that the calcium hardness be reduced to a very low value. Such a requirement suggests a considerable excess of soda ash in the water during treatment and an initial removal of calcium hardness to a low figure. A system of repeated additions and precipitations of small additional quantities of calcium hardness could then be used to reduce the radioactive strontium to a very low amount. The authors have chosen to call this the "repeated-precipitation process."

Repeated-Precipitation Process

To be acceptable for human consumption, radiostrontium removals in water supplies must be of an order higher than 99.9 per cent. Ideally, the treatment of a radioactive water should reduce the level of strontium radioactivity to that of the natural (usually termed "background") radioactivity of waters. Such removals of radiostrontium are possible and practical by modifications of the lime-soda softening process (*8*).

Though a maximum removal of only 80–90 per cent may be obtained in the initial softening reaction, a secondary process which provides for the addition and elimination of small quantities of calcium in several steps removes an equal percentage of activity with each stage. For instance, in a plant of ten stages, with only 50 per cent removal of activity in each stage, 99.9 per cent of the initial activity would be removed. In fifteen such stages, 99.996 per cent removal could be obtained.

In pursuing the research reported here, many tests using the repeated-precipitation process were made. In hot lime-soda softening, with temperatures over 90°C, it was observed that the addition of enough soda ash to provide a 50-ppm excess (as $CaCO_3$)

TABLE 1

Effect of Stable Strontium and Calcium Carbonate Crystal on Radio-Strontium Removal

Ca^{++} *mg**	CO_3^{--} *mg**	Stable Strontium *ppm*	Radiostrontium Removed *per cent*	
			Aragonite†	Calcite†
25	17	10	38	57
25	17	1.0	41	54
25	17	0.1	41	54
25	17	0.01	41	56
25	17	0.001	43	57
25	17	0.000	42	53
25	33	10	95	81
25	33	1.0	95	84
25	33	0.1	97	84
25	33	0.01	98	83
25	33	0.001	97	83
25	33	0.000	99	84

* As $CaCO_3$.
† $CaCO_3$ crystal type.

over that required to react with noncarbonate hardness, and of enough lime to provide a pH of 9.8–10.0 *at equilibrium,* resulted in a reduction of calcium hardness to 5 ppm or less and a reduction of strontium activity by 95 per cent or more. Following this initial precipitation, ten equal 5-ppm increments of calcium chloride (as $CaCO_3$) were added to react with the excess soda ash. These were spaced at 2-min intervals to cause formation

of precipitates between additions. In this way an initial strontium activity of 200 counts per second was reduced to a level essentially that of the natural background.

Equal reductions in strontium activity were obtained with cold lime-soda softening. The experimental procedure was similar to that used with hot-process softening. Enough lime was added to the raw water to obtain a pH level of 9.8–10.0 *at equilibrium*, and 50–100 ppm soda ash was added in excess of that required to react with the noncarbonate hardness. Following the initial softening, ten or more increments of calcium chloride were added to react with the excess soda ash. Equilibrium could be reached in the cold process, however, only after many hours of reaction time unless 1,000–2,000 ppm of preformed calcite crystals were added to the solution to accelerate the reaction, as explained in the preceding paper (see this issue, p. 487). Rapid stirring was necessary to increase the reaction rate further and to keep the crystals in suspension. With the high level of preformed crystals and with vigorous stirring, the increments of calcium chloride could be spaced at 5-min intervals, resulting in excellent removal of radiostrontium.

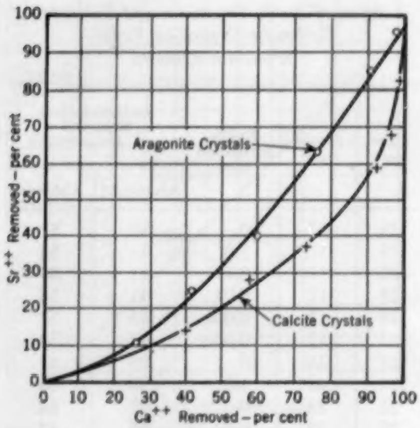

Fig. 3. Calcium and Strontium Removal With Aragonite and Calcite Crystal Formation

Aragonite crystals are more effective than calcite for removing strontium by coprecipitation.

During the course of these studies, a small pilot plant for lime-soda softening was built. By using 2,000 ppm or more of contact solids (preformed crystals) in the mixing basin, and by maintaining a pH of 9.8–10.2 in the reaction basin, calcium hardness could be reduced to the range of 18–25 ppm without the use of soda ash above the amount required to react with noncarbonate hardness. Operating the pilot plant in this manner, a removal of about 25 per cent of the strontium activity was obtained. Removal of strontium activity by the pilot plant was increased to 50 per cent by the addition of 50 ppm of excess soda ash to reduce the effluent hardness to 12 ppm. This was the best removal of radioactive strontium that could be obtained in one pass through the pilot plant, even though it was doing a better job of softening than most large, well operated full-scale plants. Only by the process of repeated precipitation could radiostrontium be reduced from a high level of activity to tolerance levels in a lime-soda softening installation.

Practical Applications

A successful laboratory procedure for removing radiostrontium by lime-soda softening has been described. It has been shown that this procedure is one by which radioactivity from strontium (Sr^{90}) ions can be reduced from high levels to near background. The

process is one of initial softening to a very low calcium residual, followed by a series of stages in which very small quantities of calcium are added and precipitated in the presence of preformed crystals of calcium carbonate. In each stage, 50 per cent or more of the strontium activity is removed. After ten or more such stages strontium activity may be reduced to extremely low levels.

Many conventional water softening plants using separate mixing, coagulation, and settling basins can be readily modified to provide for the multistage process. This can be accomplished by adding more soda ash than required for reacting with noncarbonate hardness in the initial stage of softening, and by feeding small quantities of calcium chloride solution at a number of points toward the end of the coagulation basin. In an emergency, addition of calcium chloride may be done by use of temporary pipes laid down for this purpose, with a spacing of about 5 ft along the path of flow of the treated water. The suggested flow diagram for the repeated-precipitation process is shown in Fig. 4.

A further requirement for successful operation is the presence of about 1,000 ppm or more of calcium carbonate crystals to catalyze the softening reaction. These may be added by the recirculation of calcium carbonate sludge from the settling basins, and will accelerate the softening process. Studies reported in the preceding paper (see this issue, p. 490) have shown that, with recirculated solids, a maximum reduction of bicarbonate hardness may be obtained by softening under near-equilibrium conditions at a pH of about 9.8–10.2. This procedure will reduce calcium hardness to a value of 20 ppm or less without adding excess soda ash. The addition of soda ash above the amount required to react with the noncarbonate calcium hardness should result in a further decrease in the calcium content of the water.

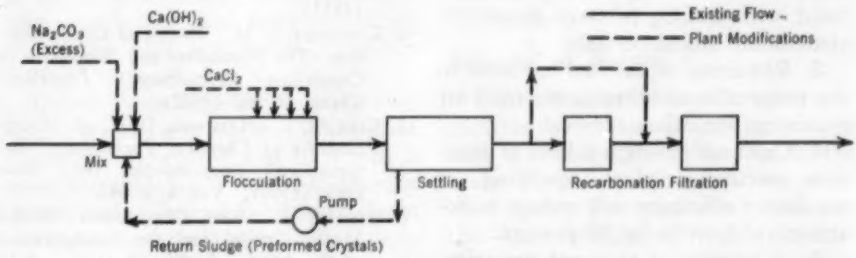

Fig. 4. Flow Diagram for Repeated-Precipitation Process

The solid line indicates the flow in conventional softening plants. The broken line shows the flow after modifications.

No further provision for recirculation of solids in modern solids-contact plants is necessary, because preformed crystals are always present in the coagulation zones. It may be difficult, however, to practice repeated precipitation by the addition of small increments of calcium chloride solution in the reaction and coagulation zones. Field experiments would have to be conducted to determine the feasibility of such operation. Regardless of the

type of plant, reduction of calcium hardness to a low level is imperative for satisfactory removal of radiostrontium. High removals of strontium activity (more than 99 per cent) were observed only in those cold lime-soda softening tests in which preformed crystals were present, and in which repeated precipitation was practiced.

Conclusions

1. Radiostrontium ions can be coprecipitated with $CaCO_3$ to form calcite-strontianite mixed crystals in the cold lime-soda process.

2. In the hot lime-soda process, radiostrontium ions can be coprecipitated with $CaCO_3$ to form aragonite-strontianite mixed crystals.

3. Reduction of calcium hardness to the point of equilibrium is essential for maximum strontium removal.

4. One pass through a lime or lime-soda softening plant operating at maximum efficiency will reduce radiostrontium activity by 50 per cent.

5. A process of repeated precipitation of $CaCO_3$ will remove more than 99 per cent of the activity from radiostrontium ions.

6. The presence of up to 10 ppm of stable isotopes of strontium will not interfere with radiostrontium removal.

7. Water treatment plants having separate mixing, coagulation, and settling facilities (whether used for alum, iron, or lime treatment) could be adapted to employ the repeated-precipitation process for coprecipitation of calcium and strontium carbonate, and thus assure maximum removal of radiostrontium.

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Beaver Activity and Water Quality

George Malben and H. B. Foote

A paper presented on Apr. 24, 1954, at the Montana Section Meeting, Bozeman, Mont., by George Malben, Supt., Water Works Dept., Helena, Mont., and H. B. Foote, on leave of absence from the State Board of Health, Helena, Mont.

BEAVER have been considered a pest when found living on and damming the streams supplying water to Helena, Mont. In the past such dams have generally been destroyed after the beaver had been caught by the State Fish and Game Dept. or licensed trappers.

Debris from beaver activities clog intake screens and valves. When their dams are dynamited and torn out, a great accumulation of strongly odorous black muck is released. Beaver create small impoundments with shallow flow. There is a rise in water temperature, along with growth of small animals and other forms of life, leading to probable odor production in the water. Figure 1 shows part of a beaver pond with surrounding vegetation.

Since 1940 health officials have been concerned over the possibility that tularemia might attack humans through the water supply. Investigations were conducted by the US Public Health Service (*1*) at Hamilton, Mont. The Montana Livestock San. Board (*2*) also studied the problem. The deaths of many beaver and muskrat from tularemia were definitely connected with the presence of the organism *Pasteurella tularensis* in the mud and water of creeks, ponds, and lakes. These bacteria are frequently found even though no dead beaver are present.

Although the work of Foote (*3*) and associates demonstrated the efficacy of chlorination in destroying the harmful organism, it is considered wise, where practicable, to eliminate that burden on the disinfection process.

Removal of Beaver

Under Montana law, all beaver and muskrat are state property, and as such are under the protection of the State Fish and Game Commission. This agency has cooperated with city and state boards of health in safeguarding the public against all known and suspected effects of beaver which might lower the quality of public water supplies. The commission has never, to the authors' knowledge, failed to issue permits for the destruction of beaver dams upon request.

Members of the US Forest Service, as well as ordinary citizens, have expressed the belief that beaver dams are beneficial to the watersheds. These structures serve to slow the flow of water, allowing it to seep into the ground. The growth of vegetation is encouraged, reducing erosion. Where such beneficial aspects outweigh any deleterious effects, the dams should be left undisturbed. The experience of various water supply operators, however, has led to the conclusion that, in some circumstances, beaver cause an

increase in the chlorine demand of water. The Anaconda, Mont., water department, in particular, has long noted the changes occurring in a nearby stream containing beaver.

Location of Study

The authors desired to locate a situation where the effects of beaver could be studied to gather precise knowledge and data. Work of this type has been carried on since August 1953 at Moose

Fig. 1. Beaver Pond on Moose Creek

Vegetation surrounds and partly overhangs this beaver pond. Much organic matter in the water comes from this source.

Creek (Fig. 2), a small mountain stream 15 miles from Helena, which seemed best suited for the purpose. Moose Creek, a tributary of Ten Mile Creek that becomes at times a part of the Helena water supply, drains approximately 3.3 sq miles of generally steep mountain slopes covered with native timber—Douglas fir on the lower portions and lodgepole pine on the upper. A hay meadow of about 25 acres lies in the lowest portion, where there are beaver dams and ponds. The entire area, except for 160 acres, is federally owned.

During the period of study no one was living in the area. The owner of the private land visited it occasionally on weekends and during the hay harvest. A pit privy, high on the hillside behind his house there, had no significant effect on the water.

Except for two horses, there was practically no domestic stock of any kind in the area during the period of

Fig. 2. Water Supply Intake

The city of Helena, Mont., at times taps Moose Creek for its water supply.

study. On one occasion there was some evidence that cows had crossed the valley below the dams. The horses usually remained near the barns and apparently did not approach the ponds. Haying was done with power equipment.

The private land, including the dams and ponds, is enclosed by a barbed-wire fence. The gate across the only access road (which terminates at the house) is kept locked at all times. Bear, deer, and elk roam the region at will. They

doubtless feed in the meadow and drink from the waters. Beaver and muskrat inhabit the ponds, along with frogs and very small fish. Insects are abundant in the summer, as are aquatic flora and fauna, practically none of which would have been present if the beaver had not impounded the water. This aquatic life, of course, also affected the condition of the stream. On Aug. 12, 1953, a representative of the State Fish and Game Commission estimated that a total of not more than four beaver and eight muskrat inhabited the ponds.

Although during the summer months air temperatures were normal, in February unseasonably warm weather (60°F) may have caused considerable runoff. It had been hoped that quantitative, as well as qualitative, data regarding the effects of beaver on the water could be obtained, but climatic and geologic factors prevented accuracy in quantitative determinations. Observations during the winter were restricted by snow and severe weather.

TABLE 1

Water Analyses

Item	Station 1			Station 2			Station 3			Station 4		
	1953	1954		1953	1954		1953	1954		1953	1954	
	Aug.*	2/9	3/23	Aug.*	2/9	3/23	Aug.*	2/9	3/23	Aug.*	2/9	3/23
Temp.—°F												
Water	54	32	32	71	36	34	67	32	35	63	34	33
Air	70	60	34	71	62	38	73	60	36	71	58	38
Color—*units*	7	20	10	37	45	15	35	30	20	30	25	15
Odor												
Hot	0	0	0	§	0	0	‖	0		0	0	0
Cold	0	0	0			0		0	0	0	0	0
pH	7.6	7.5	7.0	7.5	6.9	6.9	7.6	6.9	7.0	8.0	6.9	7.3
Cl_2 Demand—*ppm*												
10 min	0.0	0.2	0.0	0.65	0.4	0.0	0.75	0.0	0.0	0.6	0.0	0.0
20 min	0.15	0.3	0.0	0.80	1.2	0.0	0.80	0.2	0.0	0.8	0.2	0.0
30 min	0.30	0.6	0.0	1.10	1.4	0.0	1.10	0.3	0.0	1.0	0.3	0.0
60 min	0.40	0.9	0.0	1.60	1.6	0.0	1.50	0.4	0.0	1.4	0.5	0.0
120 min	0.30	1.2	0.1	1.70	1.95	0.0	1.70	0.5	0.4	1.4	0.7	0.1
240 min			0.6			0.8			0.5			0.3
300 min			1.0			1.0			1.3			0.5
Algae†—*No./ml*	97			50			65			40		
CO_2‡—*ppm*	3.0	1.0	4.0	6.0	1.0	10.0	4.6	1.0	5.0	2.6	1.0	3.0
HCO_3—*ppm*	93.5	76.3	85.4	91.5	70.2	79.3	95.6	76.3	79.3	91.5	73.0	73.0
Hardness—*ppm*	84.5	76.0	76.0	84.0	64.0	72.0	82.0	80.0	74.0	81.0	75.0	70.0
Chlorides—*ppm*	2.5	9.0	4.0	2.3	4.0	3.0	2.5	3.0	3.0	2.2	2.5	2.5
Dissolved solids	181.0	153.0	220.0	180.0	156.6	177.0	168.0	159.0	202.0	151.0	188.0	180.0
Loss on ignition—*ppm*	36.0	17.0	80.0	53.0	48.0	52.0	50.0	35.0	88.0	46.0	89.0	67.0
Loss on ignition—%	20.0	24.5	26.5	30.0	31.0	29.4	30.0	22.0	43.0	30.4	47.0	37.0
DO—*ppm*	8.7	6.3	8.4	7.7	8.0	9.0	6.8	7.0	8.2	7.5	7.9	10.6
O saturation—%	89.6	50.0	65.0	97.6	80.0	72.0	83.1	54.0	67.0	90.0	63.0	83.0
5-day DO variation—%	93.7	80.0	107.0	92.3	67.0	91.0	97.0	84.0	85.0	97.5	88.6	88.7
Bacteria												
Coliform—*MPN/100 ml*	120	530	430	190	420	430	600	750	390	340	530	0
Total—*No./ml*	118	200	60	255	150	50	192	600	90	170	300	20

* Three-sample average.
† All types of microscopic forms.
‡ Field determined, except during cold weather.
§ Swampy.
‖ Faint swampy.

It appears that there is no storage of water upstream from the dams. During August the creek flow diminished and later ceased. An abundance of shallow ground water in the area where the dams are present causes the volume of the stream to increase. On

Aug. 21, 1953, a weir measurement of the stream at the entrance to the ponds showed a flow of 0.045 cfs. On the same date a reading of 0.32 cfs was obtained downstream, at Station No. 4. (The sequence of stations is shown in Fig. 3.) There is a small spring just above Station No. 4, and a heavy growth of deciduous trees and other plants in the area also indicates the presence of considerable ground water.

Numerous chemical, biological, and physical characteristics of the water were investigated. Especially significant were the determinations on dissolved oxygen, loss on ignition, and chlorine demand. Table 1 summarizes the data found.

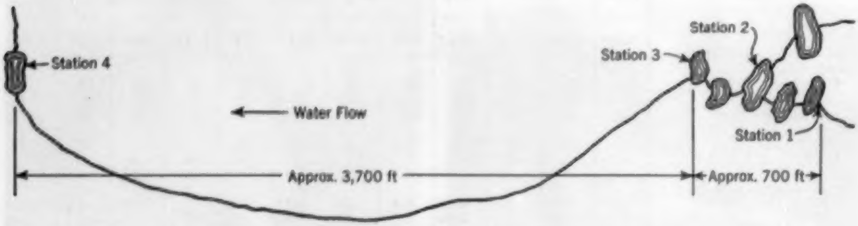

Fig. 3. Beaver Area of Moose Creek

Shown here are the locations of six beaver ponds and the four stations at which research data were gathered. The drawing is not to scale.

Findings

1. The quality of the water in the stream under study has been affected by the beaver impoundments and the existing animal and vegetable life. Organic matter was present in the water in considerable quantities, with marked color. Coliform and other bacteria increased considerably in the pond area.

2. Dissolved oxygen fluctuated in amount but never became seriously depleted.

3. Chlorine demand increased measurably. This condition, which occurs wherever beaver are found is undesirable from the economic viewpoint, but does not seem to reduce the palatability of the finished water.

4. The water temperature increased considerably during the summer months. In the winter, an ice covering maintained a more constant temperature.

5. Impoundment effects were more pronounced in summer than in winter. Animal and vegetable life was more active during the warm weather, of course, and lack of runoff from ice-locked land in the winter reduced the accumulation of organic material.

6. The authors were unable to show any exact quantitative relationship between the amount of animal life in the region and the total effects on the water. There would seem to be a relation, because animals contribute bacteria and would be present during the period of greatest impoundment activity. Also, the larger the quantity of water, the more contact there would be between animals and water.

Conclusions

As the presence of beaver may be accompanied by deleterious effects on

a stream, the animal may have to be removed from its habitat, unless the effects are negligible or can be readily corrected. Beaver dams may sometimes actually aid a water works by reducing the turbidity of streams used as a source of supply.

Tularemia bacteria were not present in significant quantity in the stream under study, but in other locations heavy chlorination might be required to counter this hazard. Because beaver activites result in a higher chlorine demand, the process of disinfection would have to be very carefully controlled.

Acknowledgments

The authors were greatly aided in sampling and analysis of the stream water by Mathew Klein, Ludwig Champa, and James Williams, all of the Montana Board of Health, as well as by Glen Kohls of the US Public Health Service. Also of assistance were A. D. Moir, Supervisor, Helena National Forest, and Wayne Fitzwater, Montana Fish and Game Dept.

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Survey of Water Utility Employment Conditions, 1954

AWWA Staff Report

DURING spring and summer 1954, the membership of AWWA cooperated in a questionnaire survey of employment conditions in the water industry. A questionnaire, approved by the Board of Directors in January 1954, was devised to obtain some fundamental facts about members on such diverse subjects as [1] age, [2] education, [3] professional affiliations, [4] tenure of office, [5] salaries, [6] civil service status, [7] retirement plan, [8] collective bargaining, and [9] safety programs. Approximately 9,500 questionnaires were sent to all the members of the Association living in the United States, Canada, and Cuba. After returns of almost 5,000 completed forms over a 2-month period, a followup mailing was sent to the tardy members. This resulted in a good response, indicated by the total of 6,503 completed questionnaires. Of this figure, 6,111 were received from members in the United States, 376 from Canadian, and 16 from Cuban members (Table 1).

TABLE 1

Completed Questionnaires by Areas

Geographic Location	Operators	Nonoperators	Total
Me., N.H., Vt., Mass., R.I., Conn.	65	97	162
N.Y., Pa., N.J.	469	617	1,086
Md., Del., Va., W.Va., N.C., S.C., Ga., Fla., D.C.	363	488	851
Ky., Tenn., Ala., Miss.	130	111	241
Wis., Ill., Ind., Ohio, Mich.	673	625	1,298
Minn., Iowa, Mo., Kan., Neb., N.D., S.D.	328	285	613
Ark., La., Okla., Tex.	282	286	568
Mont., Idaho, Wyo., Nev., Utah, Colo., Ariz., N.M.	107	106	213
Wash., Ore., Calif., Alaska, T.H.	610	469	1,079
N.B., N.S., Newf., P.E.I.	20	17	37
Que.	16	36	52
Ont.	120	94	214
Man., Sask., Alta.	17	15	32
B.C.	25	16	41
Cuba	4	12	16
Total	3,229	3,274	6,503

The questionnaire was divided into two parts. One covered water utility employees only, referred to as operators. Included in this group were: [1] superintendent, the top administrative officer of a water utility; [2] assistant superintendent, assistant to the top administrator; [3] division head, a man who takes directions from the superintendent or his assistant and is responsible for the operation of such portions of a utility system as the commercial, treatment, pumping, distribution, and meter divisions; [4] supervisor, an employee who takes directions from the division head and is responsible for the operation of a subdivision; and [5] operator, a person who takes orders from a supervisor—a laboratory technician (under a chief

technician) or an assistant station operator (under a chief operator) may be considered in this class.

The second part of the form embraced members other than water utility employees and referred to them as nonoperators. In this group were consulting engineers, teachers, manufacturers and their representatives, contractors, health department employees, city officials, other public employees, and all members whose occupations fell in fields related to water supply rather than being directly in it. In all, 3,229 operators and 3,274 nonoperators returned completed forms.

As shown in Table 2, the largest number of both operators and nonoperators fell in the 41–50 age bracket, representing 31 and 29 per cent of the totals. Both groups were alike, too, in that the great majority of their members fell within the three brackets covering ages 31–60. This range included 78 per cent of the operators and 77 per cent of the nonoperators. In the "over

TABLE 2

Age of AWWA Members

Position or Type of Work	Age—years						
	Under 30	31–40	41–50	51–60	61–70	Over 70	Total
	Operators						
Superintendent	47	234	465	454	274	39	1,513
Assistant superintendent	21	57	96	73	17	3	267
Division head	31	115	209	222	82	19	678
Supervisor	29	85	151	118	44	10	437
Operator	13	24	22	21	5	3	88
Other	2	10	11	28	18	5	74
Total	143	525	954	916	440	79	3,057
	Nonoperators						
Chief executive of political subdivision	3	20	25	17	10		75
Consultant (member of firm)	10	121	196	187	124	45	683
Employee of consultant	37	73	47	28	21	5	211
Teaching	10	36	46	21	12	3	128
Health dept. employee	38	99	122	50	23	3	335
Public employee,* not water utility or health dept.	29	72	113	89	32	6	341
Manufacturing†	104	280	263	226	86	8	967
Industrial water supply employee	8	26	25	15	5		79
Contractor	14	31	44	36	8	2	135
Other	23	50	62	49	33	33	250
Total	276	808	943	718	354	105	3,214

* City, county, district, state, and federal.
† Administrative, technical department, sales, and others.

TABLE 3

Educational Qualifications

1	2	3	4	5	6	7	8
Highest Grade Completed	Operators		Nonoperators		Combined Total		Ratio Col. 3 : Col. 5
	No.	*per cent*	No.	*per cent*	No.	*per cent*	
Grade 8 or lower	273	8.9	49	1.5	322	5.1	1:0.17
Part of high school	258	8.4	77	2.4	335	5.3	1:0.28
High school	662	21.6	187	5.8	849	13.5	1:0.27
Part of college	517	16.9	320	9.9	837	13.3	1:0.59
College	993	32.4	1,464	45.3	2,457	39.0	1:1.4
Post graduate course, 1 year or more	357	11.8	1,140	35.1	1,497	23.8	1:2.97
Total	3,060	100.0	3,237	100.0	6,297	100.0	

TABLE 4

Training Courses Taken

Position or Type of Work*	Correspondence					In-Service Training									Combined Total
	Number Taken					Number Taken									
	1	2	3	4	Total	1	2	3	4	5	6	7	8	Total	
	Operators														
Superintendent	221	134	52	49	841	93	102	61	62	24	23	9	39	1,361	2,202
Asst. supt.	40	23	5	13	153	21	28	15	13	6	7	1	7	309	462
Div. head	85	70	27	23	388	51	53	41	29	19	14	8	16	759	1,147
Supervisor	57	32	14	13	215	32	29	28	23	17	11	6	29	691	906
Operator	15	3	2	1	31	10	9	6	4	4	4		3	130	161
Other	5	11		5	47		8	3	2			1		40	87
Total	423	273	100	104	1,675	207	229	154	133	70	59	25	94	3,290	4,965
	Nonoperators														
Chief exec. of polit. subdiv.	13	9	5	3	58	4	9	5	2	1	1		1	64	122
Consultant	42	35	8	21	220	15	14	5	9	1			16	227	447
Empl. of consult.	11	11	5	1	52	4	8	3	1	3	1	1	3	85	137
Teaching	3	4		4	27	4	4	3	2	2	2		3	75	102
Health dept. empl.	14	4	3	2	39	33	36	16	17	9	11	3	20	513	552
Pub. empl., not water util. or health dept.	30	25	13	9	155	17	34	21	12	8		1	5	283	438
Manufacturing	117	59	29	24	408	65	56	28	35	10	10	4	14	651	1,059
Industr. supply empl.	10	10	8	3	66	6	3	6		4	3		3	92	158
Contractor	20	9	3	7	75	4	6	6	5	2			1	72	147
Other	17	11	7	5	80	11	18	3	8	5	3	1	3	162	242
Total	277	177	81	79	1,180	163	188	96	91	45	31	10	69	2,224	3,404

* See Table 2 for unabbreviated listings.

70" bracket, 2.6 per cent of the operators and 3.3 per cent of the nonoperators, and in the "30 or less" section, 4.7 per cent of the operators and 8.6 per cent of the nonoperators accounted for the balance of those responding. If it is true that the period from 30 through 60 is the prime of working life, more than three-fourths of AWWA members are in their prime.

operators as nonoperators in the "high school and part college" group, and four times as many in the "less than high school" brackets. An attempt to compensate for lack of adequate educational preparation by the operators is indicated by the data of Table 4, which shows that the operators have taken great advantage of correspondence and in-service training courses.

TABLE 5

Professional Society Memberships *

Position or Type of Work†	ASCE	ASME	AIEE	NSPE	AICE	ACS	APWA	APHA	FSIWA	Other	Total
						Operators					
Superintendent	156	24	61	157	4	10	99	18	112	232	873
Asst. supt.	39	3	9	24		9	8	6	19	47	164
Div. head	100	14	5	58	3	36	20	25	50	100	411
Supervisor	38	4	3	16	4	27	8	12	25	47	184
Operator	3					2	1	1	1	6	14
Others	5	1	1	4		1		2	3	21	38
Total	341	46	79	259	11	85	136	64	210	453	1,684
						Nonoperators					
Chief exec. of polit. subdiv.	19	1	3	13	1		14	3	7	28	89
Consultant	409	40	19	309	13	43	70	62	234	150	1,349
Empl. of consult.	126	3	4	54	3	6	3	5	79	28	311
Teaching	84	8	2	30	6	19	4	38	85	35	311
Health dept. empl.	109	2		75		14	3	166	211	47	627
Pub. empl., not water util. or health dept.	122	2	9	51	3	23	38	29	92	78	447
Manufacturing	111	66	16	78	34	121	11	20	174	209	840
Industr. supply empl.	5	2	1	5	8	15		2	17	20	75
Contractor	24	7	1	17	1	2		2	7	33	94
Other	66	14	10	26	10	30	9	22	53	81	321
Total	1,075	145	65	658	79	273	152	349	959	709	4,464

* ASCE, American Society of Civil Engrs.; ASME, American Society of Mechanical Engrs.; AIEE, American Inst. of Electrical Engrs.; NSPE, National Society of Professional Engrs.; AICE, American Inst. of Chemical Engrs.; ACS, American Chemical Society; APWA, American Public Works Assn.; APHA, American Public Health Assn.; FSIWA, Federation of Sewage and Industrial Wastes Assns.

† See Table 2 for unabbreviated listings.

The statistics on formal education (Table 3) reveal that 62.8 per cent of those reporting had at least a college education. In this total, however, the percentage of nonoperators is almost twice that of operators—80.4 per cent to 44.2 per cent. This superiority in educational qualifications on the part of the nonoperators shows up, too, in the fact that there are twice as many

A total attendance at 8,362 training courses was reported by the 6,503 members who answered the questionnaire.

The affiliation of AWWA members with other professional societies (Table 5) indicates strong interest in engineering and chemistry. A membership of more than 3,000 in engineering-related societies, and more than 400 in chemistry organizations, was reported.

The almost 1,200 memberships held by AWWA members in the Federation of Sewage and Industrial Wastes Assns. clearly indicates the community of interest between water and sewage works fields.

In records of tenure (Table 6), it was the consulting engineers who were on top, as 33 per cent of the 682 consultants reporting have been in business for more than 30 years. Among the operators, the largest group, 24 per cent, included those with 20–29 years of experience in water utility work, and 22 and 20 per cent, respectively, reported 10–19 and 5–9 years of experience. Only 17 per cent of the operators indicated less than 5 years of experience; 16 per cent had had more than 30 years. Altogether, the information on tenure demonstrates the stability of employment in the water works field. An apparent explanation for their long tenure was the fact that consulting engineers had the top salaries (Table 7), with 44 per cent in the "over $15,000" range. Among the nonoperators as a whole, the largest group (20 per cent) was in the $7,201–$9,000 range; the next (18 per cent) over $15,000; and the third, between $9,001 and $12,000. Operators were a little less fortunate as a whole, their largest group (26 per cent) fall-

TABLE 6

Tenure of Office

Position or Type of Work*	Under 5 Yr	5–9 Yr	10–19 Yr	20–29 Yr	Over 30 Yr	Total
	Operators					
Superintendent	306	327	313	321	239	1,506
Asst. supt.	55	51	64	77	30	277
Div. head	80	110	157	192	133	672
Supervisor	60	89	112	116	61	438
Operator	24	27	19	10	9	89
Other	7	15	16	24	12	74
Total	532	619	681	740	484	3,056
	Nonoperators					
Chief exec. of polit. subdiv.	17	29	9	14	7	76
Consultant	41	99	158	159	225	682
Empl. of consult.	40	54	54	29	34	211
Teaching	18	34	33	22	20	127
Health dept. empl.	43	86	112	60	43	344
Pub. empl., not water util. or health dept.	73	55	93	80	43	344
Manufacturing	161	228	240	195	145	969
Industr. supply empl.	14	15	34	11	5	79
Contractor	12	24	36	40	25	137
Other	32	56	55	41	59	243
Total	451	680	824	651	606	3,212

* See Table 2 for unabbreviated listings.

ing in the \$4,801–\$6,000 bracket, followed by 19 per cent in the \$6,000–\$7,200 and 18 per cent in the \$3,601–\$4,800 ranges. Only 1 per cent of the operators earned more than \$15,000. Table 8 gives breakdown of salaries for the superintendents of water utilities by town size. In Table 9, the salary ranges of 2,945 water utility employees by position and size of utility (town population) are recorded. It is believed that the number of salaries presented is large enough to make the results statistically significant.

Some correlation between compensation and educational qualifications can be seen in the comparison of Tables 3 and 10. Reference to Column 4 of Table 10 shows that the salary balance between operators and nonoperators is reached somewhere in the salary range \$7,201–\$9,000. Above the balance line, the operators predominate; below it, the nonoperators are in the majority. A similar comparison of formal educational qualifications (Table 3) puts the balance line between "Part of College" and "College"; the nonoperators are foremost in the categories below the balance point, and the operators above it. It is clearly seen that the group with the higher education has higher pay.

Civil service status is shown in Table 11. Coverage among the operators ranges up to 50 per cent, the higher amounts occurring in the lower echelon jobs. The very low percentage of superintendents covered undoubtedly is a reflection of the appointive nature of

TABLE 7

Salary per Year

Position or Type of Work*	Salary Range—\$ Under 1,800	1,801–2,400	2,401–3,600	3,601–4,800	4,801–6,000	6,001–7,200	7,201–9,000	9,001–12,000	12,001–15,000	Over 15,000	Total
	Operators										
Superintendent	18	14	109	271	351	288	226	147	40	26	1,490
Asst. supt.		2	10	46	74	54	52	26	5	7	276
Div. head	1	2	41	120	190	147	109	51	12	3	676
Supervisor	3	4	46	96	143	89	47	10	1		439
Operator	5	6	33	22	18	2		1			87
Other	3	4	1	9	13	9	12	13	6	4	74
Total	30	32	240	564	789	589	446	248	64	40	3,042
	Nonoperators										
Chief exec. of polit. subdiv.				8	9	14	23	14	11	5	84
Consultant	6	2	4	7	31	40	71	118	93	293	665
Empl. of consult.	1		2	10	37	36	51	50	15	9	211
Teaching		2		7	21	26	36	23	8	3	126
Health dept. empl.	2		4	48	66	94	77	45	5		339
Pub. empl., not water util. or health dept.			3	21	62	79	121	50	5	5	348
Manufacturing				41	113	120	175	193	125	194	961
Industr. supply empl.			1	3	12	31	20	8	3	2	80
Contractor		2	1	3	13	15	11	25	16	50	136
Other	7	3	5	15	42	39	51	42	20	20	244
Total	16	9	20	163	406	494	636	568	301	581	3,194

* See Table 2 for unabbreviated listings.

the job in many localities. Coverage is insignificant among the nonoperators, except for the two public-employee groups.

As shown in Table 12, approximately two-thirds of the members who reported are covered by a retirement program, with 72 per cent of the operators and 58 per cent of the nonoperators enjoying that protection. The most common retirement age specified is 65, the range from 61 to 65 taking in 65 per cent of all the plans. Column 9, Table 12, indicates that 77 per cent of the retirement plans are contributory—86 per cent cover-

TABLE 8

Superintendents' Salaries by Town Size

Town Population *1,000's*	Salary Range—$										
	Under 1,800	1,801–2,400	2,401–3,600	3,601–4,800	4,801–6,000	6,001–7,200	7,201–9,000	9,001–12,000	12,001–15,000	Over 15,000	Total
	No. of Superintendents										
Under 5	17	7	82	139*	76	22	9	1	2	1	356
5–10		1	19	72	117*	56	31	13	1	1	311
10–25	1	3	8	39	91	93*	66	24	4	2	331
25–50			1	14	45	65*	41	20	3		189
50–100		1		4	14	31	41*	23	5	6	125
100–500				1	8	16	34	49*	11	8	127
500–1,000						1	1	10*	6	1	19
Over 1,000				1		2	1	4	5	7*	20
Total	18	12	110	270	351	286	224	144	37	26	1,478

* Mode of the salary range for each town size.

TABLE 9

Operators' Salaries by Position and Town Size

Position	Town Size *1,000's*	Salary Range—$										
		Under 1,800	1,801–2,400	2,401–3,600	3,601–4,800	4,801–6,000	6,001–7,200	7,201–9,000	9,001–12,000	12,001–15,000	Over 15,000	Total
		No. of Operators										
Superintendent	Under 5	17	7	82	139	76	22	9	1	2	1	356
Superintendent	5–50	1	4	28	125	253	214	138	57	8	3	831
Superintendent	Over 50		1		6	22	50	77	86	27	22	291
Asst. supt.	Under 5			3	6	1	1					11
Asst. supt.	5–50			5	28	45	16	9	1	1		105
Asst. supt.	Over 50			2	12	28	38	42	24	4	7	157
Division head	Under 5		1	22	18	6	3		1			51
Division head	5–50			17	71	70	32	12	3			205
Division head	Over 50	1		2	29	114	111	97	46	12	3	415
Supervisor	Under 5	2	4	22	24	16	5	2				75
Supervisor	5–50			20	34	37	6	2				99
Supervisor	Over 50	1		4	37	89	78	42	10	1		262
Operator	Under 5	4	4	10	4	1			1			24
Operator	5–50	1	2	14	8	3						28
Operator	Over 50			9	10	14	2					35
Total		27	23	240	551	775	578	430	230	55	36	2,945

ing operators and 67 per cent, nonoperators. Although the greatest number of nonoperators contribute 6 per cent or more only 31 per cent of the operators have to put in that high a percentage. In more than 75 per cent of the plans, total salary is the base upon which contributions are determined.

The ratio of public to private ownership (Table 13) in the utilities represented is approximately 5 to 1. In administrative setup (last two columns of Table 14) the publicly owned

TABLE 10

Salaries of Operators and Nonoperators

1	2	3	4
Salary Range $	Operators *per cent*	Non-operators *per cent*	Ratio Col. 2:Col. 3
Under 1,800	1.0	0.5	1:0.5
1,801–2,400	1.0	0.3	1:0.3
2,401–3,600	7.9	0.6	1:0.07
3,601–4,800	18.5	5.1	1:0.28
4,801–6,000	26.0	12.8	1:0.49
6,001–7,200	19.3	15.5	1:0.8
7,201–9,000	14.7	20.0	1:1.36
9,001–12,000	8.1	17.7	1:2.2
12,001–15,000	2.1	9.4	1:4.5
Over 15,000	1.3	18.1	1:13.9

utilities include: 43 per cent in which the superintendent is directly responsible to an independent board or commission; 28 per cent where he reports to the city council; 15 per cent, to the city manager; 7 per cent, to a commissioner of public works; 5 per cent, to a mayor; and 2 per cent, to other administrative bodies. Most surprising is the prominence of the independent board or commission.

Except for the highest salary bracket, the city manager administration provides the greatest compensation for superintendents, although none receives over $15,000 under this setup (Fig. 1). The lowest salaries are paid by city council administrations.

The rather even distribution of members among the eight population groups covered (Table 13) would seem to weight the figures in favor of the larger

TABLE 11

Civil Service Status

Position or Type of Work*	Under Civil Service: Yes	Under Civil Service: No	Total
	Operators		
Superintendent	229	1,259	1,488
Asst. supt.	70	201	271
Div. head	268	404	672
Supervisor	221	211	432
Operator	34	54	88
Other	15	58	73
Total	837	2,187	3,024
	Nonoperators		
Chief exec. of polit. subdiv.	3	73	76
Consultant	8	655	663
Empl. of consult.	7	201	208
Teaching	6	122	128
Health dept. empl.	248	82	330
Pub. empl., not water util. or health dept.	211	134	345
Manufacturing	6	951	957
Industr. supply empl.	2	83	85
Contractor	2	128	130
Other	16	215	231
Total	509	2,644	3,153

* See Table 2 for unabbreviated listings.

cities, as approximately 93 per cent of United States' water utilities serve towns of less than 10,000 population. The distribution is not quite as bad as the 32 per cent employed in the under 10,000 category would suggest, however, for the larger utilities, of course,

TABLE 12—*Retirement Plan*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Position or Type of Work*	Coverage		Retirement Age—*year*					Contribution		Per Cent of Salary Contributed							Basis of Contributions	
	Yes	No	55 or Under	56–60	61–65	66–70	Total, Col. 4–7	Yes	No	1–1.9	2–2.9	3–3.9	4–4.9	5–5.9	6+	Total, Col. 11–16	Total Salary	Partial Salary
								Operators										
Superintendent	969	478	72	125	615	164	976	926	153	55	185	94	107	214	244	899	596	229
Asst. supt.	198	64	15	36	126	22	199	181	32	16	23	39	23	37	48	186	130	29
Div. head	537	116	58	85	317	72	532	501	77	34	53	49	62	123	165	486	362	82
Supervisor	346	76	24	60	230	37	351	332	48	12	36	28	43	81	129	329	252	40
Operator	56	29	9	11	33	5	58	56	11	3	9	6	3	17	15	53	47	3
Other	58	13	4	3	39	12	58	46	15	3	13	7	2	5	13	43	39	5
Total	2,164	776	182	320	1,360	312	2,174	2,042	336	123	319	223	240	477	614	1,996	1,426	388
								Nonoperators										
Chief exec. of polit. subdiv.	57	19	4	13	28	10	55	53	4	2	17	2	5	8	19	53	36	16
Consultant	105	571	5	6	64	26	101	57	90	2	15	8	8	9	14	56	31	22
Empl. of consult.	53	158		2	40	9	51	28	28	2	13	4		5	1	25	11	14
Teaching	116	11	4	6	57	45	112	106	14	1	10	7	14	46	27	105	80	24
Health dept. empl.	312	23	30	63	171	44	308	275	35	14	26	24	27	89	93	273	190	81
Pub. empl., not water util. or health dept.	303	43	35	55	163	39	292	285	15	7	23	14	21	65	154	284	242	36
Manufacturing	633	332	4	26	515	81	626	334	345	39	88	75	54	27	35	318	235	76
Industr. supply empl.	71	7	1	3	60	8	72	49	25	6	6	18	9	1	6	46	31	15
Contractor	36	100		5	25	4	34	20	29	3	2	1	5	5	4	20	16	5
Other	172	76	6	15	115	31	167	100	76	2	16	22	14	12	25	91	62	17
Total	1,858	1,340	89	194	1,238	297	1,818	1,307	661	78	216	175	157	267	378	1,271	934	306

* See Table 2 for unabbreviated listings.

have a good bit more than 7 per cent of the employees. At any rate, it appears evident that AWWA membership is not general enough in the smaller communities.

The union affiliations of operator members shown in Table 15 indicate that unionization has reached only 5 per cent of the members in the United States and Canada, half of the union members being affiliated with the American Federation of Labor. In order of frequency of unionization, the utility divisions involved were: [1]

TABLE 13

AWWA Membership, by Type and Size of Utility

1	2	3	4	5	6	7	8	9	10	11	12	13
Position	Utility			Population Served by Utility—*1,000's*								
	Public	Private	Total, Col. 2–3	5 or less	5–10	10–25	25–50	50–100	100–500	500–1,000	Over 1,000	Total, Col. 5–12
	Operators											
Superintendent	1,271	219	1,490	362	315	335	191	124	129	19	20	1,495
Asst. supt.	198	76	274	11	28	39	38	54	71	19	13	273
Div. head	549	128	677	52	53	81	72	66	200	64	86	674
Supervisor	391	48	439	75	33	40	27	22	78	49	111	435
Operator	83	6	89	25	11	8	9	6	7	7	15	88
Other	43	30	73	6	1	7	9	6	23	8	13	73
Total	2,535	507	3,042	531	441	510	346	278	508	166	258	3,038

TABLE 14

Superintendents' Salaries, by Type of Utility Administration

Administration	Salaries—$											
	1,800 or Under	1,801–2,400	2,401–3,600	3,601–4,800	4,801–6,000	6,001–7,200	7,201–9,000	9,001–12,000	12,001–15,000	Over 15,000	Total	Per Cent of Total
	No. of Superintendents											
Mayor			8	10	16	14	7	2		1	58	5
Administrative officer*			4	25	53	45	35	24	10		196	15
Comr. of public works	1	1	1	15	26	22	15	10	3		94	7
City council	6	3	47	101	80	50	42	16	1	1	347	28
Independent board†	6	5	37	95	134	110	85	60	15	8	555	43
Other				3	8	3	5	7			26	2
Total	13	9	97	249	317	244	189	119	29	10	1,276	100

* Such as city manager.
† Or commission.

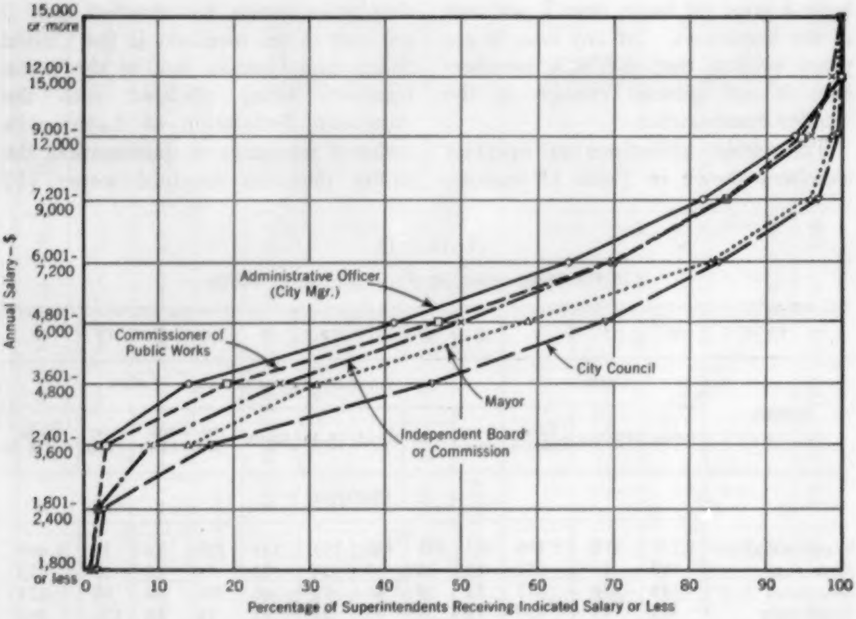

Fig. 1. Superintendents' Salaries, by Type of Utility Administration

The city manager setup is the most advantageous, financially, to the superintendent. See Table 14 for a tabular presentation of the material shown above.

TABLE 15

Union Affiliation of Operators

Affiliation	US	Canada	Cuba	Total
CIO	16			16
AFL	63	3		66
Eng. unions	12	2		14
Public employee unions	13	2		15
Other unions				27
Total				138
Nonaffiliated	2,705	172	3	2,880

meter and transportation (equal); [2] distribution; [3] commercial; [4] engineering; [5] pumping and [6] treatment.

A total of 632 utilities reported that they had an active safety program; 835 indicated that they did not. Although the 43 per cent "Yes" is encouraging, it does indicate the need for much work in this field. It is hoped that the facts developed by this survey will stimulate study and action in an attempt to correct at least some of the weakest areas of activity.

Crossing the Threshold is An Important Step...

A Threshold Odor Test is the only known way to evaluate your success in removing disagreeable tastes and odors from your water. Frequent odor surveys are essential to insure *constantly* palatable water. Technicians from INDUSTRIAL, *as part of their regular services*, will assist you in the application techniques of AQUA NUCHAR.

The dosage of AQUA NUCHAR—activated carbon—needed to provide palatable water will depend upon the many varying conditions which determine the state of the raw water supply. Waterworks operators realize that partial reduction of odors may not produce palatable water. In fact, the average individual will be fortunate to detect the difference between waters having Threshold Odor values of 50 and 25. Therefore, sufficient activated carbon must be applied at the right time and place to reduce the threshold number to a value of 5 or less. Complete reduction of detectable odors (Threshold Odor of 5 or less) will eliminate complaints and may even result in compliments on the water quality.

INDUSTRIAL'S Research and Technical Group are available to you (without obligation) when you face odor problems.

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LARGE METER *Capacity*
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No proud father would argue that twins are as easy to take care of as one. That's one reason Neptune Trident Style 3 meters are recommended in place of compound meters for 1½" and 2" service lines. The Style 3 disc meter is accurate down to exceptionally low flows, and handles high flows with ease.

The simpler Style 3 meter maintains accuracy longer, and repairs (when necessary) are easier. Modern Style 3 parts fit older meters. There's no obsolescence . . . you modernize as you go.

And its lower initial cost gives you a nice saving. So why use two meters when one will do the job?

Style 3 meters were the first to feature a special pressure adjustment. In high-pressure lines, the outlet of the meter is throttled to prevent overspeeding, and in low pressure installations, the outlet is opened wide to minimize loss of head.

Proof of the accuracy and efficiency of the Trident Style 3 will be found in your own testing equipment . . . in lower maintenance costs . . . and in increased revenue.

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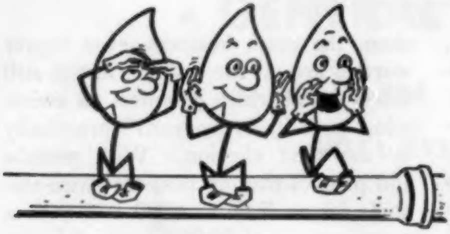


Percolation and Runoff

30,000,000 orphans sound like the price of revenge rather than reciprocity, but it was against a reciprocal trade act proposal to grant tariff concessions on foreign-made water meters that representatives of the domestic meter industry assessed this rather terrifying toll. That the orphans will be meters rather than men is, of course, comforting, although the probable process of parenticide could hardly have sounded so to members of the Tariff Commission and Committee for Reciprocity Information before whom Dante Broggi, President of Neptune Meter Co., described it last Mar. 30 in Washington, as spokesman for most of the meter industry and its workers. Essence of his argument was that foreign industry, benefiting by much lower labor costs, would be able to undersell domestic manufacturers and, thereby—primarily because 70 per cent of water meter customers are required to buy from the low bidder—capture the entire market in a short time. Such capture, Mr. Broggi pointed out, would quickly put the present domestic manufacturers out of business, making unavailable spare parts for the more than 30,000,000 meters now installed—making orphans of them, that is. Further orphaning would be involved, of course, if foreign supplies were later cut off by war or other emergency, with serious effects on water supply conservation at the very time when it would be most needed.

On hand to protest the threat to the parents of the prospective American orphans were Morrison B. Cunningham, superintendent and engineer of the Oklahoma City water department, and James G. Carns, meter specialist for the American Water Works Service Co. Based on their extensive experience and their knowledge of the viewpoint of the water works field, they pointed out to the tariff committee the seriousness of the losses that would be involved if present meters had to be scrapped for lack of spare parts, the false economy of "cheap" meters, and the importance of the individualized service and counsel now available to customers from the domestic meter manufacturers as a result of their long experience in the field and their close relationship with its personnel.

Attesting, too, to the character of the parents was an AWWA resolution which called the attention of the Tariff Commission to the importance of the domestic water meter industry not only to the water works field, but to the nation as a whole, and recommended continued tariff protection in the national interest.

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

All the expertation went for naught, however, for a week later the commission decided to grant the tariff concessions and was off to Geneva to negotiate the necessary treaties. Meanwhile, the industry back home was busy figuring out ways to make its own dire predictions untrue. And knowing the seven prolific parents of our multimillion meters, we have an idea they'll soon find a means of preventing our water works from becoming large-scale orphanages.

"A bath for every bedroom" seems to have become the new symbol of our prosperity. Not since the days of "a chicken in every pot" have we sought to express our high standard of living in such—well, bare—essentials. The new "bath," too, is more than just a "bathroom"; it has a tub or, at the very least, a stall shower, and bathers almost every day. Somehow the tub has gained a tremendous amount of popularity since the Saturday nights that we remember. This could, of course, be the result of Hollywood glamorization, as all the fancy soaps and salts and bubbles and perfumes would seem to suggest, but we're a little more inclined to guess it's because we really need the baths. True, our medieval ancestors got along with three in a lifetime—at birth, at marriage, and at death—but they didn't have to worry about what their best friends wouldn't tell them. Nor were nerves then as frayed and fragrant as ours can't help but be.

With this application of the "one-a-day" principle meaning 36 gal in every tub and 25 gal in every shower, water workers who have anything to work with should be prospering. For those who are worried rather than elated about the extra business, even bigger worries are on the horizon in the still newer trend which promises "a swimming pool in every yard" practically by the next election. With prefabs and plastics making possible swim-size pools for as little as $200 and with a manufacturer of $2,000 pools claiming sales of 600 for the coming year, it shouldn't be too long now before everybody who is anybody at all will have caught up with the Davy Jones's.

Rather than worry, though, no matter how unhappy the local water situation, every water works man will do well to get on the bathwagon—to get in the swim. After all, the customer who has invested in four baths and a pool isn't going to put up with a water shortage for very long if he's shown that something can be done about it, and relatively inexpensively, too. "Water for every tub and pool" doesn't have to be a luxury either.

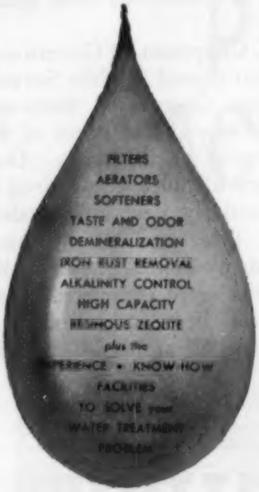
A Junior Sanitary Engineer competitive examination, open to all qualified US citizens, has been announced by the New York State Dept. of Civil Service. The salary range is $4,350–$5,460. Detailed information can be obtained from the Examinations Div., New York State Dept. of Civil Service, 39 Columbia Street, Albany 7, N.Y. (refer to "No. 144, Junior Sanitary Engineer").

Worthington Corp., Harrison, N.J., announces that its Wellsville Works and Steam Turbine Sales Div. are being merged and will be known as the Steam Turbine Div. Arthur F. Reinking, manager of the sales division, has been appointed general manager of the new division.

(*Continued on page 38 P&R*)

A GENERAL FILTER

WATER TREATMENT PLANT WILL FIT YOUR NEEDS LIKE A *Prescription!*



That's right! General Filter actually prescribes a water treatment plant to fit the individual needs and requirements of each industry or municipality . . . designs, engineers and constructs it to assure an adequate supply of *pure* water . . . to provide dependable, economical, trouble-free operation over the years.

That's why more and more industries and municipalities are installing General Filter water treatment plants. They *know* they can depend on General Filter to solve their problem the *right* way. No job is too big or too small. General Filter's field-trained water specialists will *prescribe* a plant . . . its experienced engineers will *design it* and its skilled construction engineers will *build it* to fit your needs exactly.

Find out how General Filter solves Water Treatment problems for Industries and Municipalities . . . Find out how General Filter can solve yours.

Write today for complete information . . . no obligation . . .

General Filter Company

AMES, IOWA

"yours for better water"

(Continued from page 36 P&R)

Radioactive digout—not fallout—has been the cause of more than considerable excitement on the Denver, Colo., watershed of late—and the happy note is that the contamination is strictly prefissional. Uranium ore it is—and a rich strike at that, with assays up to $1,850 per ton compared to the $50 per ton ore now being mined in many places, not to mention the $0.05 per ton stuff usually handled by the water department. At last reports, negotiations for development of the strike on the basis of a royalty payment to the Denver Water Board were being sought by Manager E. L. Mosley with a lot less concern than he usually feels in seeking a lot less money in higher rates. All of which suggests that the Denver bonanza is going to sell many, many more Geiger counters than all the ominous urgings of civilian defense authorities ever did. And even if they never lead to another strike, they'll be worth their weight in digout as detectors of fallout—or even putin.

Frank W. Chapman, of Greenwood, S.C., has been named "Public Servant No. 1" by the Greenwood Rotarians for his work as superintendent of the commissioners of public works. During his tenure of office (he retired in 1952), an entirely new and modern filter plant, three sewage treatment plants, and many improvements in the electric system were completed. Mr. Chapman has been a member of AWWA since 1925 and is a past chairman of the Southeastern Section.

(Continued on page 40 P&R)

DeZURIK
WATER-WORKS
PLUG VALVES
LEAK-FREE
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EASIEST
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Despite sand and silt, DeZurik Non-Lubricated Plug Valves seal tight without binding, without scoring!

The rubber-faced plug, in combination with exclusive eccentric action, provides dead-tight shut-off, sealing *around* particles in the flow.

Write for information.

DeZURIK SHOWER CO.
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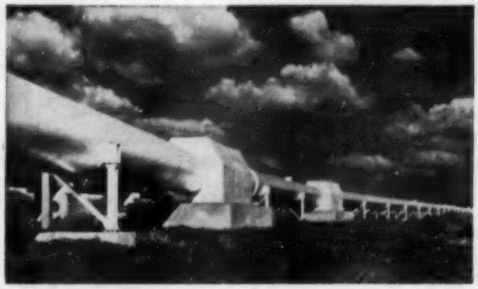
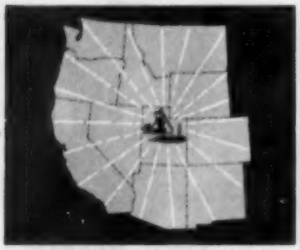
SEE US IN BOOTHS 161–162 AT THE AWWA CONVENTION

FROM NEW "HUB OF THE WEST" SOURCE...

USS QUALITY PIPE KEEPS PACE WITH THE WEST



Consolidated Western's new plant serves the entire West with Water Pipe



With the opening of its new Utah plant now under construction on a 117 acre site near Provo, Consolidated Western Steel has once again expanded its facilities to keep pace with the need for pipe to build the West's great projects . . . like the giant new Mokelumne Aqueduct. This vital conduit reaches 170,000 feet across the fertile Sacramento Valley into the reservoirs of the East Bay Municipal Water District, Oakland, California. Built from 69" diameter Consolidated Western welded steel pipe—the new Mokelumne is one of the West's most modern waterways.

Because United States Steel always emphasizes quality control from mine to mill to finished steel . . . its consistently high-quality steel pipe is in demand the world over. For 100 years, Consolidated Western Steel, Division United States Steel, has pioneered the fabrication, erection and manufacture of pipe, structural steel, plate products and mechanical equipment—constantly proving that only steel can do so many jobs so well.

The new plant at Provo, Utah is ideally located to serve you with the greatest possible efficiency. It will produce and deliver the highest quality electric-welded steel pipe at the lowest possible cost. Sizes available include 4" to 40" diameters in lengths up to 50 feet to meet the needs of domestic water systems, industrial and agricultural installations.

CONSOLIDATED WESTERN STEEL

Sales Offices: Los Angeles, San Francisco, Fresno, Bakersfield, California; Phoenix, Arizona; Seattle, Washington; Houston, Texas.

DIVISION

UNITED STATES STEEL

USS

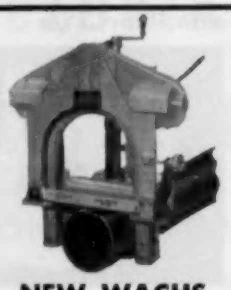
(Continued from page 38 P&R)

W-Day for ASCE was May 2, the day on which William H. "Pete" Wisely officially took over as executive secretary of the American Society of Civil Engineers. He succeeded Col. William N. Carey, who held the post ten years and is retiring as executive secretary-emeritus. Wisely has been serving as ASCE associate secretary since the first of the year, having previously been executive secretary of the Federation of Sewage & Industrial Wastes Assns.

W. H. Wisely

The US Public Health Service has announced a number of changes in personnel assignments: Gordon E. McCallum has been named head of the Water Pollution Control Program, Washington headquarters. Mr. McCallum's former position as chief of the Office of Health Emergency Planning is being taken by John B. Hozier, medical consultant. Alfred H. Wieters, assistant chief of the Water Pollution Control Program, Washington headquarters, has left to become a consultant on pollution control to the Brazilian Ministry of Health, Rio de

(Continued on page 42 P&R)



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CONTINUOUS PIPELINE CHEMICAL MIXING

THE HOMOMIX—provides instant, violent, uniform, and complete mixing of one or more chemicals or gases with water—continuously or intermittently, *without the use of a mixing tank!* Designed with one or more stages of direct-connected motor driven diffuser impellers rotating in blending chambers, it forms part of the influent piping. Discharges directly across the flow-through stream. Mixes instantaneously at the point of entry. Lift impeller can be added to provide additional head, if required. *Send for Technical Supplement HM and Bulletin 300.*

IRON AND CARBON DIOXIDE REMOVAL

THE FERROFILTER—removes iron, manganese, carbon dioxide, and other dissolved gases and odors—efficiently and economically, in one simple operation. Utilizes fine media in open aeration. *Write for Bulletin No. 252B.*

SOFTENING AND TURBIDITY REMOVAL

THE FLOCSETTLER—combines in one unit all modern concepts of water and waste treatment, including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. *Send for Technical Supplement FL.*

RAPID MIX AND FLOCCULATION UNITS

PADDLE-PROPELLER-RM TYPE MIXERS—for rapid mixing to obtain continuous blending of chemical with raw water.

PADDLE-DOWNFLO-FLOCCULATION UNITS—designed to efficiently carry out the slow mixing and flocculation functions required in the coagulation process. Choice of vertical and horizontal units. *Send for Technical Supplement PF.*

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POSITIVE FLIGHT CONVEYORS—for rectangular settling tanks. Heavy-duty solid shafting, babbitted plate sprockets. Heavy adjustable self-aligning wall bearings, furnished with foundation bolts welded to templates and eccentric washers for economical installation.

CIRCULAR CLARIFIERS—Structural steel bridge, steel flights in staggered position mounted on two radial trussed arms driven by motorized gear reduction unit. *Write for Bulletin 253B.*

PUMPS

Complete line of double-suction split-case single-stage, two-stage, end suction, axial flow, sludge, and deep well turbine pumps—for wide range of raw water, low lift, high lift, backwash, and general service pumping requirements. *Send for Bulletins 248A, 246A, 251A, 245A.*

Working Model of Homomix on Display in Booth 16-17 A.W.W.A. Convention Chicago, June 12-17

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Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

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(*Continued from page 40 P&R*)

Janeiro. Ralph J. Johnson, chief of housing hygiene activities, Div. of Sanitary Engineering Services, Washington headquarters, has resigned to become director of the Research Institute and Construction Dept., National Assn. of Home Builders, Washington. E. Carl Warhentin and William E. Holy have been named regional engineer and assistant regional engineer, respectively, at the Dallas Regional Office. The former regional engineer there, E. C. Anderson, has been appointed assistant chief of the Radiological Health Branch, Div. of Sanitary Engineering Services, Washington. Robert R. Harris, chief of the Water Pollution Control Basin Office at Portland, Ore., has been named chief of the Water Supply Branch, Div. of Sanitary Engineering Services, Washington headquarters.

A self-propelled air compressor, in the 125-cfm class, has been placed on the market by Schramm, Inc., West Chester, Pa., under the trade name "Standard Pneumatractor." The fob factory price is $3,675.

"How do you rate?" is, or certainly should be, a pretty scientific sort of question these days, to be answered in such analytical terms as those used by Dick Hazen in the higher-browed pages of last month's JOURNAL (see p. 310). But back in the days when men were men and metermen weren't many, it apparently required more ingenuity than engineering to devise a sound

(*Continued on page 44 P&R*)

BUILDERS PROPELOFLO is an inexpensive main line meter for totalizing water consumption. Gives dependable, trouble-free service on the job. Meters accurately over wide range — six-digit totalizer shows water use directly in gallons, cubic feet, etc. For complete information on this easy-to-install meter, write to Builders-Providence, Inc., 365 Harris Ave., Providence 1, Rhode Island.

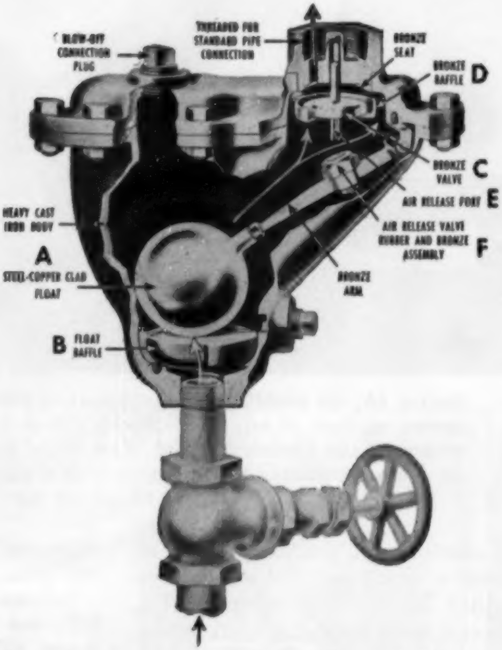
BUILDERS-PROVIDENCE

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO.

METERS FEEDERS CONTROLS

Rensselaer Combined *Air* and *Vacuum* AND *Air Release* VALVES



This Rensselaer valve is used to allow air to escape while the pipe is being filled with water; to allow air to flow into the pipe when it is being emptied of water and to allow accumulated air under pressure to escape at high points of the line.

It is used extensively for water mains, turbine pump discharge, bowls of booster pumps, air tanks and sand traps.

This valve will positively close under low water head, cannot blow shut and allows full and clear passage of air.

It is a combination vent, vacuum and pressure air valve, with all parts built for long and satisfactory service.

It is available in simplified form for air release only. Ask for bulletin No. F. 106C

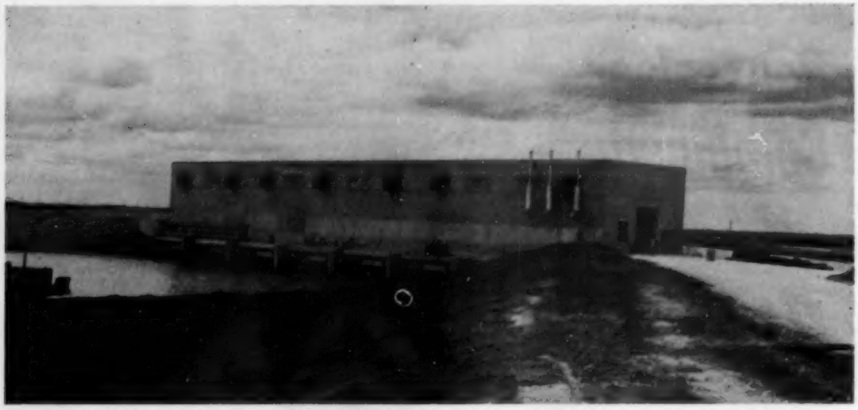
Rensselaer VALVE CO. TROY, N. Y.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

SALES REPRESENTATIVES IN PRINCIPAL CITIES

Division of The Ludlow Valve Manufacturing Co., Inc.

(Continued from page 42 P&R)



Station 5A, the world's largest self-powered pumping station, went into service on Mar. 19 as part of Florida's flood control system. Located between Lake Okeechobee and West Palm Beach, the station houses six 116-in. Fairbanks-Morse pumps with a combined capacity of more than 3 bil gal per day.

rate schedule. A product of such ingenuity at work was the schedule established by the Huntington, W.Va., city council on Nov. 22, 1886, which, among other items, set forth the following annual charges:

Banks—one faucet, \$10. Bakeries—daily average of each barrel of flour used, per barrel, \$4 (no bakery less than \$8). Barber shop—first chair and basin, \$6; each additional chair, \$3. Baths—private, without heating attachment, \$4; private, with heating apparatus, \$5; hotel or boarding house, each tub, cold, \$8; hotel or boarding house, each tub, hot, \$10; public, first tub, \$12; each additional tub, \$8. Building purposes—brick, per 1,000 laid, 10¢; stone, per perch, 7¢; plaster, per 100 yd, 30¢. Boarding house—per room, \$1.50 (no charge less than \$10).

Halls, theaters, and hotels—special rates. Laundries, \$10 to \$20. Offices—with washbasin, \$5 to \$10. Offices, printing—six hands or less, \$12; each additional hand, \$1.50. Photograph gallery—special rates. Residences—occupied by one family, six rooms or less, \$5; each additional room, 75¢. Restaurants—special rates.

Saloons—two self-closing bar faucets, \$10; one self-closing and one hose bar faucet, \$15; washbasin, self-closing faucet, \$4. Sanitary facilities—special rates. Soda fountains, \$10 to \$25. Stable—livery, boarding or sale, per horse, including carriage washing, \$2 (no charge less than \$10); private, one horse, including washing carriages, \$3; each horse, \$2; each cow, \$1.50. Steam boilers—special rates. Stores and shops, \$5 to \$20.

Seasonal Rates

Sprinkling lawns with $\frac{1}{8}$-in. nozzle 4 hr per day, 60-ft front or less, \$5; each additional front foot, 10¢. Street sprinkling (corner lots measurement on both fronts for street sprinkling), per front foot, 5¢. Fountains, to be used not over 6 hr per day for the season of 6 months—$\frac{1}{16}$-in. jet, \$8; $\frac{1}{8}$-in. jet, \$15; $\frac{3}{16}$-in. jet, \$20.

The original contract provided that the city pay \$3,000 per year for the

(Continued on page 46 P&R)

The distinctive design of the Graver Reactivator®, proven in hundreds of installations, combines *all* four of these important features in *one* unit: *1. Controlled Sludge Recirculation, 2. Separately driven Sludge Scraper, 3. Low Sludge Level, 4. Sludge removal over entire bottom area*

WRITE FOR

DESCRIPTIVE CATALOGUE WC-103A

Municipal Dept. M-113

GRAVER

GRAVER WATER CONDITIONING CO.

A Division of Graver Tank & Mfg. Co., Inc.

216 West 14th Street, New York 11, N. Y.

(*Continued from page 44 P&R*)

use of 84 hydrants and for water to the fire stations, city offices, public schools, and "fountains to be furnished by the city with self-closing valve for man and beast." The city was given permission to use the hydrants for sewer and street flushing, but no more than two hydrants were to be used for such purposes at any one time, and those for no more than 10 min at a time. For the few who had meters there was a "metro rate," which started at 40¢ per 1,000 gal for the first 1,000 gal and dropped to 15¢ per 1,000 gal for amounts over 10,000 gal —presumably per year.

What price water, indeed?

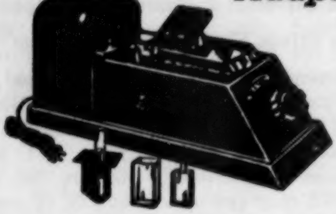
An all-silicone-rubber insulating system for large motors and generators has been announced by Allis-Chalmers Mfg. Co., Milwaukee. "Silco-Flex" insulation is said to provide a sealed, impervious dielectric barrier, continuous around the coil and leads, which forms a flexible, moisture-, chemical-, and heat-resistant wall over the entire coil structure. The insulation will be priced on the same basis as previous Class H insulations.

Julian R. Fleming, who was formerly associate professor of hydraulic and sanitary engineering at the University of Tennessee and has frequently served as a sanitary engineering consultant, has been named director of the Div. of Sanitary Engineering of the State Dept. of Public Health, Nashville, Tenn. He replaces R. P. Farrell, who died in an accident on Jan. 8, 1955.

(*Continued on page 48 P&R*)

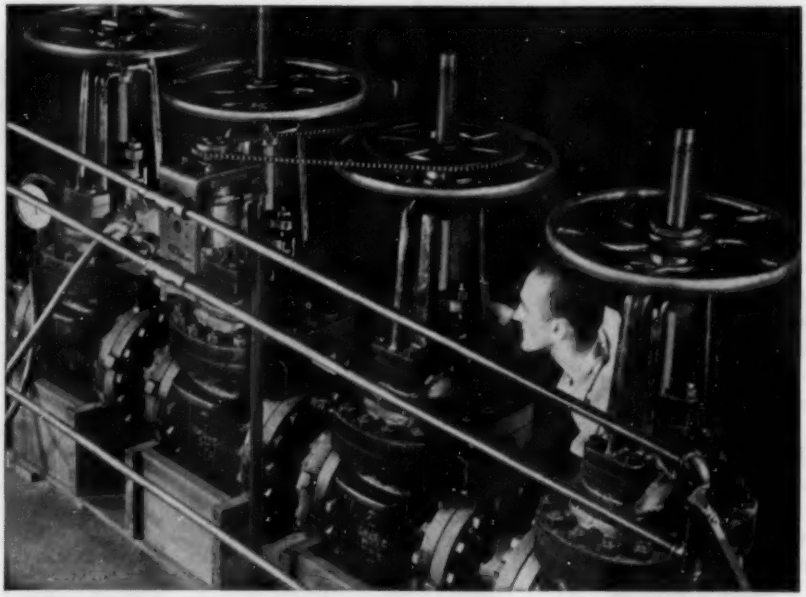
KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.



Testing . . . testing . . . 50 years and longer to make CRANE VALVES maintenance free

Testing for product performance values is an old custom with Crane. It was started long before many standards existed—long before others in the field used this means of product improvement and quality control.

Today's Crane valve testing is done in both field and laboratory by the most scientific techniques. This continuing work seeks to increase valve performance and lessen maintenance needs. A single example is the stem packing test shown above.

Here's one of the reasons back of the thrifty buyers' preference for Crane valves. They can rely on ever-improving Crane quality to protect their company's investments in piping equipment—especially today, in the face of high maintenance and repair costs. No wonder industry keeps using more Crane valves than any other make.

CRANE CO.

General Offices: 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

CRANE'S FIRST CENTURY . . . 1855-1955

(Continued from page 46 P&R)

The FSIWA—Federation of Sewage and Industrial Wastes Assns.—has moved to its new quarters at 4435 Wisconsin Ave., N.W., Washington 16, D.C. The office was formerly located in Champaign, Ill.

Edward D. Flavin has been appointed vice-president of the Johns-Manville Sales Corp., New York, and manager of special industries, Industrial Products Div. Mr. Flavin, who joined the company in 1929, succeeds the retiring L. A. Baldwin.

New York State has amended Section 77-b of its general municipal law to include improvement district boards among those bodies which can authorize and pay the expenses of their members or employees to attend conventions, conferences, or schools. In addition to travel, meals, and lodging expenses, the amendment provides for the payment of registration fees up to $5.00.

The Band-Aid for broken mains suggested in a recent issue was no time at all in coming. As a matter of fact, the suggestion was hardly out of our mouth at the time that the Celanese Corp. of America was busy bandaging a rusted-out water header at its Bishop, Tex., plant. Approximately 40 ft of pipe had eroded, with large holes in some areas and the balance almost paper thin. To repair it, the scale was first knocked off, then two plies of glass cloth, saturated with

(Continued on page 50 P&R)

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These five De Laval centrifugal pumping units, each consisting of two pumps in series, are installed in the Hays Mine Station of the South Pittsburgh Water Company. The unit in the foreground is designed for 5,400 gpm against a total head of 395 ft. at 1,200 rpm and is driven by a 600 hp motor. The other four units are identical, each designed for 9,000 gpm against a total head of 395 ft. at 1,200 rpm, and are each driven by a 1,000 hp motor.

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DL 288A

(*Continued from page 48 P&R*)

a self-curing blend of polyester resin, were applied over the large holes. Leaks were then plugged and two additional plies of resin-saturated glass cloth wrapped about the rusted area. With just 30 gal of resin and total material costs of $137.88, the pipe was restored to full service. As a matter of fact, that may be a little more like Newskin than Band-Aid, but first aid nevertheless.

A non-oily penetrant, "Puritan," for loosening corroded nuts or bolts and seized parts of mechanical equipment has been developed by Olin Mathieson Chemical Corp., Baltimore. The product, which is said to be fast acting, deeply penetrating, nonflammable, and odorless, will be available in half-pint and larger containers.

Ralph N. Thompson, former chief chemist of the Falulah Paper Co., Fitchburg, Mass., has been appointed manager of research for Calgon, Inc., and Hall Labs., Inc., chemical subsidiaries of Hagan Corp., Pittsburgh. Mr. Thompson succeeds the retiring Dr. T. H. Daugherty, who will continue as consultant.

Controlled hardness is provided by a bypass system marketed by Graver Water Conditioning Co., New York. A single setting on the adjustable orifice controls the proportionate mixing of untreated hard water and fully softened water to produce the degree of hardness desired. Valves are automatic, no pumps are used, and moving parts are kept to a minimum.

(*Continued on page 52 P&R*)

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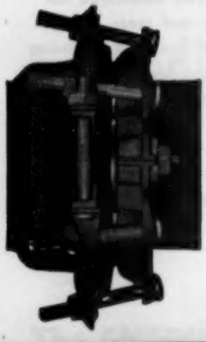

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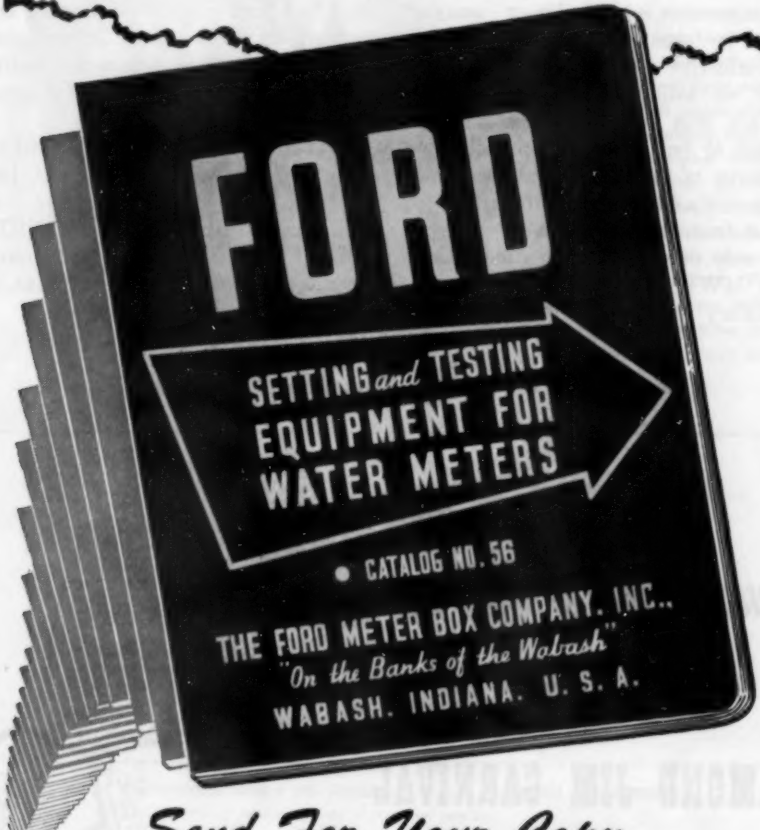

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(Continued from page 50 P&R)

A chaste taste well placed is that of Stanley Barwick of Potters Bar, Middlesex, England, for Barwick is chief taste tester for the London Metropolitan Water Board. An organist in the Assumption Church in Potters Bar, Barwick presumably doesn't mind the "life of rigorous discipline, without cigarettes, alcohol, or onions" which he must lead to protect his supersensitive palate. What a taste waste we would say were it not for the fact that his 60 sips a day are reputed to be "largely responsible for the purity of the 350 mil gal used daily by the city's 6,000,000 customers." Of course, knowing that even the chastest taste may one day spring a leek, London's MWB does well to add a precautionary shot of chlorine.

E. Paul Lange, assistant secretary of Engineers Joint Council, has been named secretary of that organization, succeeding Brig. Gen. Stewart E. Reimel, USA (Ret.), secretary of the EJC Committee on International Relations, who had been acting as temporary secretary of EJC. Mr. Lange, who has been engaged in mining engineering in various parts of the world, is a member of the American Institute of Mining and Metallurgical Engrs.

Byron Jackson Co. has elected four new vice-presidents: Norman D. Jesse, Pump Div. sales, services, and branches; Garth F. Nicolson, Oil Tool Div.; Evan H. Sweet, legal counsel; and Ross Barrett, public relations, advertising, and market research.

(Continued on page 86 P&R)

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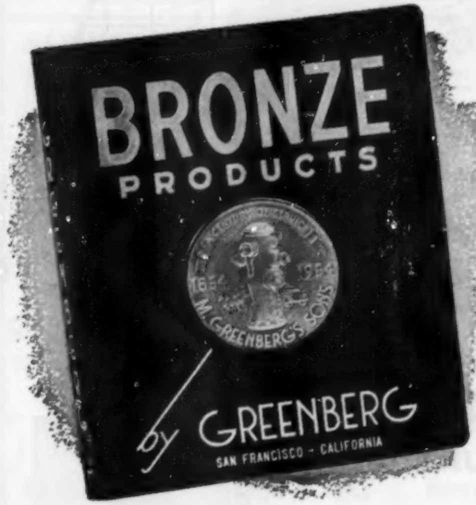

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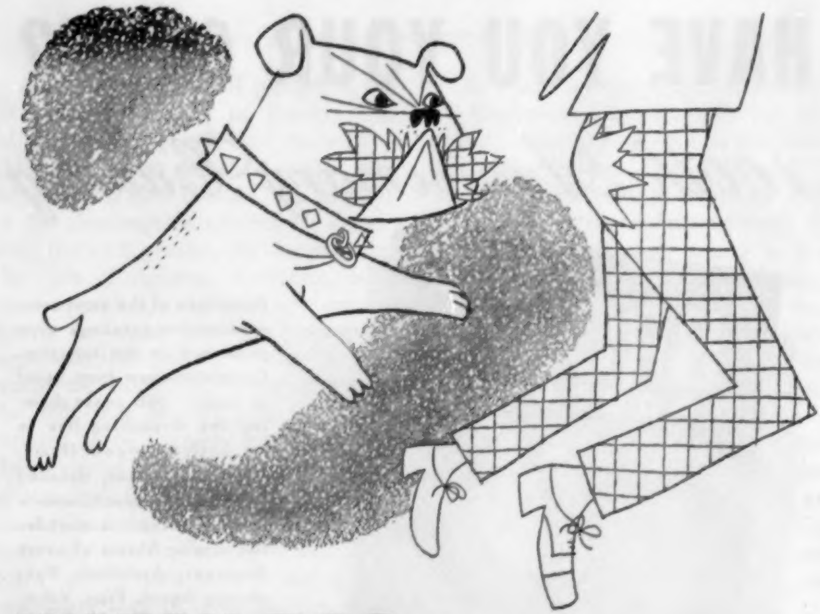

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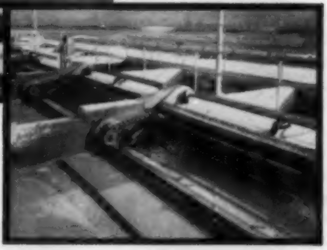

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

FLUORIDATION

Fluoride and Nonfluoride Enamel Opacities. E. R. ZIMMERMAN. Public Health Rpts., **69**:1115 ('54). Continuous resident, white children, 12–14 yr old, examined in Aurora, Ill. (water, 1.2 ppm F), and in two Maryland counties (0.2 ppm F) for dental caries experience and fluorosis. Illinois children had DMF (decayed, missing, or filled permanent teeth) rate of 2.9 and fluorosis index of 0.32; Maryland children had DMF rate of 6.4 and no fluorosis was observed. Two kinds of enamel opacities were seen: those frequently accompanying fluoride ingestion (positive and questionable fluorosis) and those of unknown or unassociated etiology (idiopathic and nonfluoride). First kind of opacity, observed only in Aurora, had affected 43% of study group (17% were "very mild" or "mild" and 26% "questionably" fluorosed). Second kind of opacity observed in 9% of Aurora children and in 36% of Maryland group. Differentiation between questionably fluorosed and idiopathic opacities was accomplished by observation of physical appearance in 94%, and by attention to pattern and frequency in remainder.—*PHEA*

A Waterborne Caries-Protective Agent Other Than Fluorine. P. ADLER & J. STRAUB. Acta Med. Acad. Sci. Hung., **4**:3-4:221 ('53). Gyoma and Devavanya, two small towns in Hungary, about 15 km apart. Anal. of drinking water from several wells at Gyoma yielded results indicating fluorine content ranging from 0.320 to 0.755 ppm, and avg fluorine intake in 1 l of water, about 0.56 ppm. At age of 14, avg DMF figure per child examd. was 1.48. At Devavanya, fluorine content found to range from 0.081 to 0.840 ppm, with average fluorine intake (excluding figures for 1 exceptional well) per child of about 0.30 ppm. At age 14, avg DMF figure per child examd. was only 0.85. Low incidence of dental caries in Devavanya was not due to increased uptake of fluorine from domestic waters by enamel in posteruptive stage. Dietary habits, social and economic status, and racial characteristics of two populations appeared to be same, so it is postulated Devavanya drinking water contains some trace element, other than fluorine, which exerts caries-inhibitory effect. Nothing, however, is known regarding its nature.—*BH*

Waterborne Fluorides and Mortality. T. L. HAGAN, M. PASTERNACK & G. C. SCHOLZ. Public Health Rpts., **69**:5:450 ('54). Report presents analysis of mortality from all causes and from five selected causes—heart disease, cancer, intracranial lesions, nephritis, and cirrhosis of liver—in 64 cities in 16 states, and compares rates in those cities in which water analyses show fluoride content to be 0.25 ppm or less with those cities where fluoride content is 0.70 ppm or more. Data show no statistically signif. difference between mortality rates of fluoride and nonfluoride cities for any of the causes studied. —*BH*

Fluoridation of Domestic Water Supplies in the Control of Dental Caries. H. H. STONES. Brit. Dental J., **96**:8:173 ('54). First half is factual account of occurrence of endemic dental fluorosis, its relation to caries incidence, and controlled fluoridation of water supplies in North America. Second part is more interesting, deals with fluoride in foods, influence of temperature on intake of fluoride, administration of fluoride in other media, mechanism of dental caries, and urinary excretion of fluoride. Refers to Galagan's comparison between Arizona, mean annual temperature of 70°F, and area round Chicago with mean annual temperature of 50°F, and his conclusion that, with mean

(*Continued on page 64*)


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(*Continued from page 62*)

temperature of 70°F, children consume twice as much water as those living where mean temperature is 50°F. For the latter temperature, optimum concentration fluoride is 1.2 ppm; for 70°F, 0.6 ppm. Administration of fluoride in tablet form or by addition to milk or other foods, such as salt, is considered but not recommended. An abnormally high amount of fluoride may be absorbed as result of dust inhalation and may produce ossifying spondylitis. Several reports have come from India on the occurrence of systemic fluorosis, but there is reason to think nutritional deficiencies there may help aggravate effect of fluoride. Paper ends with discussion of level at which storage in bones takes place and belief that storage does not produce physiologically undesirable effects. —*BH*

A Toxic Effect of Fluoride. L. M. Carr. Nature (Br.), **174**:884 ('54). Three rats fed on semisynthetic diet with vitamin supplements, while 3 other rats received same diet, including vitamins, plus 80 ppm fluoride in drinking water. At end of 3 wk no change in weights or appearances of animals was observed. In order to aid onset of biotin deficiency, diets were modified to include 16% raw egg white. At beginning of period during which diet was used, avg weights of 3 rats of control and exptl. groups were 204 and 178 g, respectively. After 16 days, avg weights were 196 and 125 g. Fur of exptl. animals was bristled and rough, and there was alopecia of snout, head, and legs, mild diffuse dermatitis, and mild "spectacle eye." Control animals showed no symptoms. Other expts. showed that: [1] 120 ppm fluorine in drinking water did not affect growth of rats during 7-week period when natural stock diet was given; and [2] if egg white was excluded from diet shortly after loss of weight began, there was no further loss of weight even though fluoride supplements were continued. In second set of expts. large amounts of fluoride ingested orally found not to affect severity of riboflavin deficiency.—*BH*

(*Continued on page 66*)

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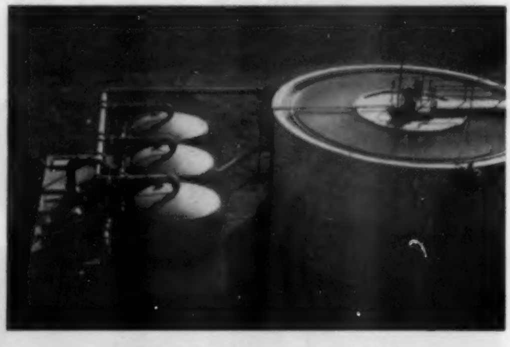

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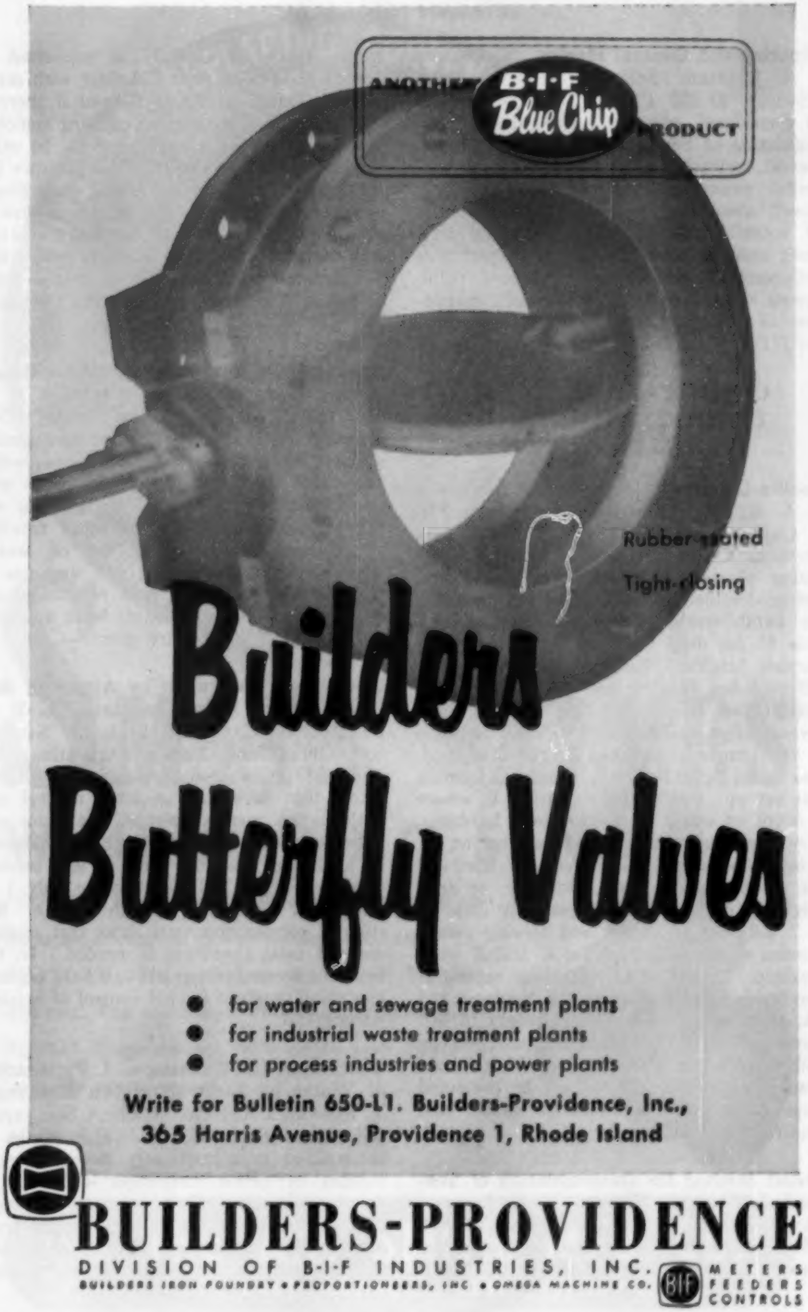
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(*Continued from page 64*)

Fluorine and General Health. V. Demole & A. J. Held. Schweiz. Med. Wochschr. (Swiss), **83**:362 ('53). Study of relation of fluoridated water and general health of population of Sembrancher. General neurological, endocrinological, dermatological, and dental examns. showed regular and continued absorption over several generations of potable water contg. 1.0–1.4 mg F/l. Both children and adults show remarkable resistance to dental caries. Recent immigrants showed no ill effects from consumption of this strength of fluoridated water. —*PHEA*

CHEMICAL FEEDING, CONDITIONING, AND SEDIMENTATION

Zeolite-Column Calculations. E. Jimeno & A. L. Ruiz. Anales Real Soc. Espan. Fís. y Quím. (Sp.), **50B**:195 ('54). Calcns. given to facilitate design of industrial softening plants. Two synthetic exchangers, one unidentified and other Zeo-Per, used for the exptl. work. Exchange columns with beds 81 cm deep were set up with taps at varying heights. Vol. of water softened at different bed heights was detd. and plotted against bed height, yielding a straightline curve. Line was extended to meet ordinate at zero capacity and bed height thus detd. was called "dead height." Empirical formula was set up: $V/10 = (H - D)C + X$, where V = vol. of water obtained of zero hardness, H = height of column, D = dead height, C = capac. of column in degrees of hardness per cm of column, and X = capac. of dead height in degrees of hardness. By detg. V at 2 different H values and solving simultaneous equations, values for C and X were obtained. Addnl. data, including regeneration levels, effects of increasing hardness and alk. salts, veloc. of flow, and height of bed given for Zeo-Per. Finally, graph, set up with 6 ordinates, is shown with which dimensions of industrial softener can be computed from basic data of exchange capac. and required yield in cu m/hr.—*CA*

Visual Method for Determination of Suspended Matter in Water. K. H. Roggenkamp. Gas- u. Wasserfach (Ger.), **95**:450 ('54). Membrane-filter app. of Beger has been redesigned in more sturdy form. Membrane (such as Coli 5) is supported on fritted glass filter plate in holder with screw joints. One l. of water is used if there is little suspended matter, 100 cc being sufficient for strongly contaminated water. In other methods, time of water flow and pressure (or suction) is kept const., giving logarithmic scale of visible impurities, or rate of flow of distd. water is detd. for standard conditions and compared with that of water under test. Membrane-filter method is especially useful for detg. flocculated Fe and Mn compds.—*CA*

Practical Performance of Water-Conditioning Gadgets. B. Q. Welder & E. P. Partridge. Ind. Eng. Chem., **46**:954 ('54). Presents observations of 7 water-conditioning gadgets in actual plant operations which show that these special devices, either with or without external elec. circuits, do not prevent scale, corrosion, or other troubles encountered in industrial use of water. Methods used to promote sale and use of gadgets are discussed, and references describing various units which have appeared on market since 1865 are given.—*CA*

Obtaining a Coagulant by Attack of Sulfuric Acid on Meta-Aluminate. L. B. de Ruella, E. Catalano & A. F. Segura. Rev. Obras Sanit. Nación (Argentina), **17**:353 ('53). By using quantities of H_2SO_4 below that necessary to form neutral salt with native meta-aluminate, coagulant obtained compares favorably with that obtained by acidifying bauxite. Cost is less because of native origin and also because only ⅓ as much acid is required as with bauxite. Results of comparative tests show that smaller dose of meta-aluminate is needed. In the resulting treated water, pH is 0.2–0.3 higher; less alkali required for pH control of finished water.—*CA*

Continuous Ion Exchange. I. Purification of Water by Electrolytic Ion Exchange. Y. Kosaka & A. Sato. J. Chem. Soc. Japan, Ind. Chem. Sect., **55**:628 ('52). Water to be purified is continuously flown through column of cation exchanger followed by anion exchanger. Two columns are sepd. by cotton cloth, and voltage is applied from outside by Pt electrodes. Method is superior in continuity and saving of exchangers.

(*Continued on page 68*)

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(*Continued from page 66*)

Strongly acidic and strongly basic resins are favorable. Applied voltage > 150 v is adequate.—*CA*

Mineral-free Water at Low Cost. ANON. Factory Management & Maintenance 112: 128 ('54). To obtain water free of suspended or dissolved solids (used for phosphor coating the face of television tubes) for ½¢/gal, treat city water (contg. approx. 100 ppm total solids as $CaCO_3$) with small concn. of alum and NaOH, forming gel that coagulates fine suspended solid matter, filter through 2 sets of sand filters and C filter, and pass through mixed-bed deionizing unit and through solids trap. Check qual. by conductivity meter, 2.5 megohms-cm resistance satisfactory. After cation and anion resins have absorbed as much mineral impurities as possible, regenerate them successively by backwashing, treating with NaOH and dil. H_2SO_4, rinsing with water, and agitating in air to mix cation and anion resins; this restores them to their original condition.—*CA*

Augmentation of Water Treatment Works. W. L. HURD. Commonwealth Eng. (Australia), **41**:231 ('54). New flocculation tank and sedimentation basin described, former concentrically located within latter. Novel features are gridded false floor between tank and basin to assist in preventing boiling up of settling flock and 88 4-in. conducting tubes to deliver flocculated water from tank, well down into sludge region of basin.—*CA*

Stability of Lead in Water. L. Y. SUSHINSKAYA. Gigiena i Sanit. (USSR), No. 8, p. 49 ('53). Best absorbent for dissolved Pb in water ($Pb(No_3)_2$ in aq. soln.) found to be clay. Pb solns. completely stable in neutral or acid solns., but in alk. soln. (pH 8.4) Pb content gradually ppts. on standing in contact with air. For removal from in-

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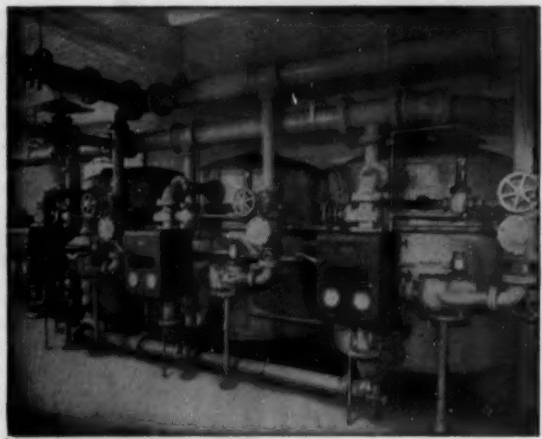

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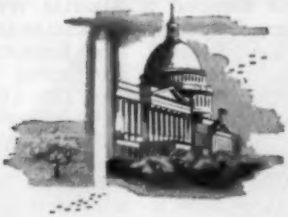

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WATER FOR GENERATIONS TO COME

(*Continued from page 68*)

dustrial liquors, alk. soln. in combination with clay adsorbent is recommended.—*CA*

Wherever Steam and Water Flow . . . Remove Scale With Chemicals. J. P. Warren. Southern Power & Ind., **72**:5: 70 ('54). Low-pressure boilers are used as evaporators, with all treated water and some contamd. condensate which is used in boilers operating at 1,250 psi, 900°F. Chem. cleaning is used for these low-pressure boilers. Acid cleaning is also used for superheater elements, and all new boilers are cleaned of grease and mill scale, acidized, and boiled out. New boiler units are so designed that economizers can only be acid cleaned. Chem. cleaning used for water jackets on air compressors. Inhibitors used in acid cleaning leave all metal surfaces in satisfactory condition and with no evidence of metal removal or attack. Oil coolers are cleaned on both oil and water sides. Accumulations are removed from anthracite filter beds of hot-process water-treating plants. Pipelines carrying salt water are also cleaned satisfactorily. Where power plants or other equipment is to be acid cleaned regularly, it is economical to install permanent piping for this purpose.—*CA*

Chemical Purification of Boiler Feedwater for the Steam Power Plant at AB Kaukas Fabrik. H. Totterman. Finska Kemistsamfundets Medd. (Finland), **62**:65 ('53). Makeup water problems at new steam plant at Kaukas, Finland, are unique in some respects. Equipped with 2 boilers operating at 900 psi and 500°, and with max. evaporative capac. of 42 tons/hr, it was designed primarily for providing process steam, and makeup often reaches 50%. Raw lake supply quality (winter and summer, resp.) in ppm: total solids, 39.0–82.0; loss on ignition, 18.0–30.6; $KMnO_4$ demand, 43.0–159.3; color, (Pt-Co) 40°–55°; pH, 7.1–6.7; hardness (German degrees, CaO/100,000), 0.8°–1.32°. Removal of org. matter which would normally be easily flocculated with alum is complicated by sulfite mill waste that acts as protective colloid. Exhaustive flocculation research with various Fe and Al salts proved that under local conditions $FeSO_4 \cdot Cl \cdot 7H_2O$ was superior to all other coagulants. Its larger and heavier floc provides effective org. matter removal even with winter waters near 0°. Feed is regulated to run parallel with $KMnO_4$ consumption. Under typical winter conditions with water temp. at 10°, water of 64.5 ppm $KMnO_4$ demand, hardness 0.88°, color 40° and pH 6.70 was treated with 175 g $FeSO_4 \cdot Cl \cdot 7H_2O$/cu m and softened with ion exchange to yield water of 13.9 $KMnO_4$ demand, hardness of 0.13°, color of 10° and pH of 6.75, acceptable in every way for high-pressure boiler demands.—*CA*

The Removal of Fluoride From Water: Rapid Removal of Fluoride With Magnesium Oxide. P. Venkateswarlu & D. N. Rao. Indian J. Med. Research, **41**:473 ('53). F content of water contg. 5–20 ppm F rapidly reduced to less than 1.0 ppm by boiling with 5.0 g/l MgO, followed by stirring. MgO contg. adsorbed F can be ignited and reused limited no. of times. $CaCO_3$, $MgCO_3$, and CaO investigated for F removal, but found not satisfactory for treating drinking water.—*CA*

Nomograph Gives Settling Rates for Spherical Particles. G. M. Machwart & R. J. Baird. Chem. Eng., **60**:12:176 ('53). By means of nomograph, based on Stoke's law, rate of sedimentation of colloidal particles can be determined. Terminal velocity of particle is obtained from difference in density between particle and fluid, diameter of particle, and viscosity of fluid.—*WPA*

SWIMMING POOLS

Studies of Bathing Water Quality and Health. A. H. Stevenson. Am. J. Public Health, **43**:529 ('53). Report given on methods used and results obtained in series of 3 studies of illness occurrence among groups doing observed amounts of swimming in waters of different bact. qual. Studies made on great lake, inland river and pool, and tidal water. Differences in swimming experience and illness incidence among various age groups are shown. Increase in illness incidence with increased swimming experience is demonstrated. Correlation between illness incidence and bact. qual. of natural bathing water was observed in 2 instances, although results cannot be taken as conclusive. Observation is made that some of strictest bact. qual. requirements for natural bathing water now existent might be relaxed

(*Continued on page 74*)

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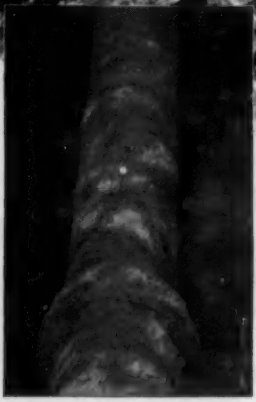

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(*Continued from page 70*)

without signif. detrimental effect on health of bather.—*PHEA*

High Free Residual Chlorine in Swimming Pool Water. E. W. Mood & E. D. Robinton. Ind. Eng. Chem., **45**:2574 ('53). High free residual chlorination effected low bact. count in both indoor and outdoor pool and was superior to marginal chlorination. High free residual chlorination kept water free of coliform bacteria while used by bathers. Small numbers of several common bacteria survived this treatment for at least limited time.—*CA*

The Sanitary Quality of the Water of Open-Air Baths. K. Haack & H. Heger. Z. Hyg. u. Infektionskr. (Ger.), **140**:3:294 ('54). Description and discussion of considerable length of results of chem. and bact. anal. of the waters of bathing places in rivers, lakes, ponds, and water in artificially constructed baths. General conclusion is that neither formulas based on analytical results nor setting up of limiting values for chem. constituents or bact. counts are of value in the judgment of hygienic quality. General opinion on quality of water can be formed by taking into account phys., chem., bact. and biol. characters of water and associating these with findings of careful inspection of bathing place and its locality.—*BH*

Human Leptospirosis Associated With a Swimming Pool, Diagnosed After Eleven Years. T. A. Cockburn et al. Am. J. Hyg., **60**:1 ('54). Disease of unknown etiology locally known as "Wycon" fever occurred in epidemic proportions in towns of Jackson, Wyo. and Ucon, Idaho, during August '42. Epidemiological and serological investigations were conducted in '53. Collective data resulted in diagnosis of leptospirosis, with *Leptospira canicola* listed as probable causative agent. Infection was contracted at swimming pool at Granite Springs, Jackson Hole, Wyo. Clinical symptoms, lab. results, and epidemiological situation are

(*Continued on page 76*)

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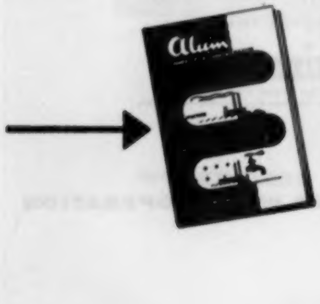

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(*Continued from page 74*)

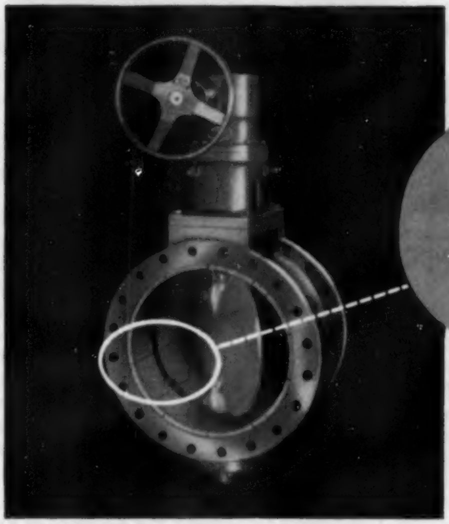
presented. High level of infection with *L. canicola* of animal population of area is suggested.—*PHEA*

The Choice of an Indicator Organism for the Bacteriological Control of Swimming Bath Purification. R. D. GRAY. Monthly Bul. Ministry of Health & Public Health Lab. Service (Br.), **12**:124 ('53). Coliform test is widely accepted for assessing potability of water and use of *Esch. coli* as indicator organism to assess effectiveness of purif. is well established. Water of swimming pool, however, is exposed to contamn. not only from intestine but also from mucous surfaces (such as nasopharynx) and from body surface itself. There have been conflicting opinions on most suitable organism to use as indicator for bact. control of swimming pool purif., and it was decided to undertake investigation. This study was limited to pools in which process of continuous circulation, filtration, and chlorination was in operation so that there could be no doubt of efficiency of purif. process. Samples were examined for presence of coliform organisms, hemolytic streptococci, staphylococci, *Neisseria catarrhalis,* and also for general bact. cleanliness by means of plate count. Free and total residual chlorine contents and pH of water were measured at time of sampling. As preliminary expt. and in order to appreciate degree of bact. polln. in bath, examns. were made of water from one swimming pool after 74 male bathers had been in water during previous 2 hr water being circulated and filtered but not chlorinated. Considerable numbers of bacteria of all types were present, as shown by plate counts at 37°C and 22°C. Conventional bact. indicators of intestinal poln. were present, but only in small numbers. Staphylococci were numerous and *Neisseria catarrhalis* was very numerous, many organisms being present in 0.5 ml of sample. Then 178 samples (72 from inlets and 106 from outlets of baths) were collected from 37 pools in 5 localities and examd. at nearby labs. in Birkenhead, Conway, London, Manchester and Oxford. Coliform organisms and *Neisseria catarrhalis* were seldom isolated from samples in which free residual chlorine exceeded 0.1 ppm. Alpha-haemolytic streptococci and staphylococci were too resistant to chlorination to be of much service as indicator organisms. Plate counts in nutrient agar at 37°C and 22°C showed close correlation with levels of free-residual chlorine. Of 138 samples in which free-residual chlorine exceeded 0.1 ppm, plate count at 37°C did not exceed 10 colonies/ml in 76.1% or 100 colonies/ml in 95.7%. Corresponding percentages for plate counts at 22°C were 79.0 and 93.5. Swimming loads appeared to have little effect in increasing bact. poln. of water and on occasions when paired samples were taken from inlet and outlet of bath, there was no appreciable difference in bact. qual. of 2 samples. As recommended std. for swimming pool water, it is suggested that no sample examined from pool should contain any coliform organisms in 100 ml of water; and that in 75% of samples examd. from that bath, plate count at 37°C from 1 ml of water should not exceed 10 colonies, and in remainder should not exceed 100 colonies. It is possible to maintain pool water at this standard with free-residual chlorine as low as 0.1 ppm, but this level allows no margin of safety and is in practice difficult to maintain. Level of 0.2–0.5 ppm recommended by the Ministry of Health should maintain swimming pool water in a bact. satisfactory condition provided chlorine is present as free-residual chlorine.—*PHEA*

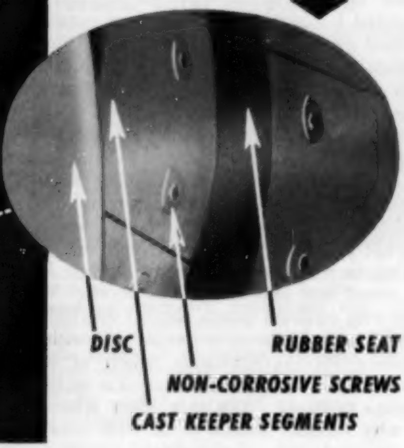
Water Quality of Swimming Places. A Review. E. L. LEHR & C. C. JOHNSON JR. Pub. Health Rpts., **69**:8:742 ('54). In '49, joint committee on bathing places of Conference of State San. Engrs. and Am. Public Health Assn. recommended certain stds. of water qual. for swimming pools: [1] residual chlorine, free available chlorine 0.4–0.6 ppm or combined available chlorine (chloramine) 0.7–1.0 ppm; [2] pH of pool should never be less than 7.0; [3] not more than 15% of samples covering any considerable period of time should have plate counts on std. nutrient agar after 24 hr incubation at 37°C. of more than 200 colonies/ml; and [4] coliform test should be negative in all of 5 10-ml portions of water set up from sample collected at time pool is in use. Committee emphasized that final classification of water in natural bathing places should depend largely upon sanitary survey information and that results of bact. anal. should be used only as guide. Without placing too much emphasis upon bact. std. of safety, committee concluded waters with coliform

(*Continued on page 78*)

125# Valves...drop tight!



HERE'S WHY



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(*Continued from page 76*)

counts less than 1,000/100 ml would be acceptable for bathing unless sanitary survey should disclose immediate dangers from human sewage. TVA has classified bathing waters according to bact. qual. but only in conjunction with sanitary surveys. Waters with coliform counts of 0–50/100 ml in absence of adverse sanitary survey can be accepted for bathing areas without question. Second group with counts of 51–500 is interpreted by TVA as state of contamn. presumably normal for inland streams which are free from sewage poln., but subject to surface washings. It is recommended that bathing be permitted in such areas in absence of adverse sanitary surveys. Counts of 501–1,000 indicate waters of suspicious qual., which are dangerous if in proximity to fresh sewage poln., but which might be considered satisfactory if careful sanitary survey fails to reveal any unfavorable conditions. Waters with coliform counts above 1,000/100 ml should not be selected for swimming without sanitary surveys disclosing origin of high count and establishing it is not due to fresh sewage contamn. Question often arises as to why variance should be so wide between water qual. stds. for artificial pools and those for natural bathing areas. This is generally explained by recognition of difference in signif. given to presence of coliform organisms in natural waters and those in artificial pools. Water used to fill swimming pools is free from coliform organisms in most instances, that is to say, is from mains of local drinking water supply. Therefore, presence of intestinal organisms in samples from these pools must be regarded as of recent human origin and of dangerous signif. On other hand, coliform organisms in natural waters may be of animal origin or from soil washings and thus be of relatively less epidemiological signif. As yet no substitute for coliform group as an indicator of poln. in bathing water has received general approval, but consensus of opinion is still that one is needed. Chlorine is most widely used disinfectant but bromine is increasing in popularity and about 1,000 pools in Southern California are using bromine as disinfectant of choice. Diatomite filters are gaining in popularity but there are those who feel that these filters have yet to pass test of time before they can be considered as good as or superior to rapid sand or pressure filters in swimming bath purif.—*BH*

BOILERS AND FEEDWATER

Prevention of Corrosion of Boiler Preheaters. I. B. Varavitskii, E. S. Ivanov & L. B. Krol. Elek. Stantsii, **23**:10:6 ('52). In high-pressure boiler installations, preheating primary air with steam from 40–45° to 85–87° eliminates condensation of flue-gas moisture and prevents corrosion of preheater tubes and clogging with ash.—*CA*

Corrosion in the Boiler. R. F. Andres. Ind. Eng. Chem., **46**:990 ('54). Resume of recent theories and practices in the chem. treatment of boiler water for corrosion control is presented. Corrosion of Fe, Cu, and Ni are reduced by elevation of feed-water pH values to 9.0 by addn. of NH_3 or amines. Pitting, caused by dissolved O, is controlled by use of Na_2SO_3 in alk. feed water. $NH_2NH_2 \cdot H_2O$ has been proposed since it is capable of elevating pH of feed water and removing dissolved O. Control of Mg and Cu deposits and of caustic embrittlement are mentioned.—*CA*

Conditions Governing the Absence of Free Carbonic Acid in Feedwater. I. K. Grishuk. Elek. Stantsii, **25**:5:6 ('54). If feed water to be deaerated contains < 0.07–0.11 mg-equiv./l of $NaHCO_3$, it is impossible to remove free H_2CO_3 in thermal deaerator. If bicarbonate alky. is over 0.3 mg-equiv./l, initial content of free H_2CO_3 before deaerator is about 2–3 mg/l, and water is in the storage tank not less than 15 min, then it is possible, under proper operating conditions, to achieve partial decompn. of bicarbonates in storage tank and, hence, almost complete absence of free H_2CO_3. Pink coloration upon addn. of phenolphthalein is not reliable indication of completeness of deaeration in deaerators to which cationized water is added.—*CA*

Internal Cleaning of Boilers. J. M. Maloney. Ind. Eng. Chem., **46**:983 ('54). Procedures are discussed for removing scales and deposits from steam boilers by chem. cleaning with 5% HCl soln. contg. surface amino- or N-S coal-tar inhibitors, with H_3PO_4, and with com. detergent composed of metaphosphate and silicate. Use of N gas to displace chem. cleaner is means of reducing after-rusting.—*CA*

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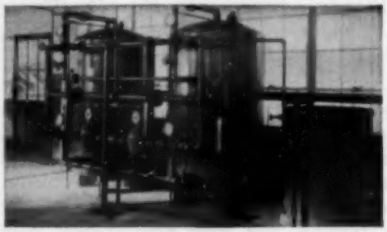

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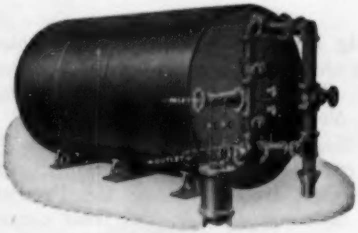

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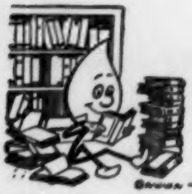

The Reading Meter

Floods. *William G. Hoyt & Walter B. Langbein. Princeton Univ. Press, Princeton, N.J. (1955) 469 pp.; $7.50*

Authors Hoyt and Langbein, of the US Geological Survey (Mr. Hoyt is now retired), have produced an instructive and readable book on floods in the United States, their history, causes, problems, and remedies. Easily understandable by the layman, the book nevertheless does justice to the technical aspects of this formidable and vital subject. The well balanced account of the factors in flood control policy, controversial * and otherwise, is materially enhanced by the authors' historical approach. A chronology of major American floods (since the sixteenth century), a geographical list of outstanding floods, and a bibliography are appended. Although not the last word on the subject (will there ever be one?), *Floods* makes worth-while reading.

Big Dam Foolishness: *The Problem of Modern Flood Control and Water Storage. Elmer T. Peterson. Devin-Adair Co., New York (1954) 224 pp.; $3.50*

"This book," says the author frankly, "is controversial and iconoclastic." As is evident from his title, Mr. Peterson has little use for big-dam flood control and its proponents. In weighing the merits of upstream (land management) and downstream ("big dam") flood control, the author exhibits an unfortunate tendency toward dogmatism and argument by label. Big dams, for example, are "bureaucratic," whereas soil conservation districts are "an excellent example of democracy in action." There is much to be said for both sides, but the issues involved are complex and such categorizing does not help to clarify them. Mr. Peterson's forceful and outspoken presentation of the defects of big dams and the virtues of small reservoirs and land management as flood control measures should be read with such a book as Hoyt and Langbein's *Floods* (reviewed above) close at hand.

* See the following review.

Hail Columbia: *The Thirty-Year Struggle for Grand Coulee Dam. George Sundborg. Macmillan Co., New York (1954) 467 pp.; $5.75*

This book relates in copious detail the tribulations and triumphs of James O'Sullivan and his fellow advocates of the building of Grand Coulee Dam, which, according to the author, is three times the size of the Great Pyramid, the world's second largest manmade structure. Mr. Sundborg has performed a labor of love that, in its own field, must be ranked, if not with the dam, certainly with the pyramid. Buried among such facts as the amount of money spent by the Columbia River Development League for its letterheads in June 1929 ($6.50) is the story of a dedicated man and the monumental edifice his efforts helped create.

Geology in Engineering. *John R. Schultz & Arthur B. Cleaves. (With a chapter on soil mechanics by E. J. Yoder.) John Wiley & Sons, Inc., New York (1955) 592 pp.; $8.75*

The object of this work is to provide a systematic account of geologic principles and methods for the benefit of the engi-

(Continued on page 82 P&R)

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The Reading Meter

(Continued from page 80 P&R)

neer. Written by two geologists, the book covers such subjects as minerals and rocks, erosion, subsurface water, frost action, landslides, soil mechanics, and dams and reservoirs. These and other topics are surveyed in some detail, but by no means comprehensively—for example, fewer than three pages are devoted to methods of estimating ground water supplies. As the authors point out, however, the primary purpose of the book is to furnish a background in geology for the engineer rather than to make a geologist out of him. For readers who want or need fuller details on specific aspects, references are given at appropriate places in the text. Taken on its own terms, the book should prove a useful addition to the engineer's library.

Conversion Factors and Tables. *O. T. Zimmerman & Irvin Lavine, ed. Industrial Research Service Inc., Masonic Bldg., Dover, N.H. (2nd ed., 1955) 502 pp.; $5.00*

Need to know how many charak in a pao, or how many ngu in a foot? This pocket-size ($4\frac{3}{8} \times 6\frac{1}{4}$-in.) handbook will tell you. The 119-page section on foreign conversion factors is only one of a number of features of this reference work. It includes, in readable format, factors and tables for weights, measures, energies, densities, hydraulic units, hardness, wire and sheet metal gages, color scale conversions for liquids, and numerous other items which the engineer or technical worker might otherwise have to leaf through several different handbooks

(Continued on page 84 P&R)

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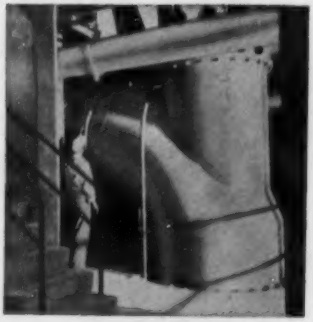

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The Reading Meter

(Continued from page 82 P&R)

to find. The index is an added time saver.

American Standard National Plumbing Code—ASA A40.8–1955. *American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y. (1955) 186 pp.; paperbound; $3.50*

This uniform code, cosponsored by ASME and APHA, is designed to modernize existing practices and to coordinate the work of equipment manufacturers, contractors, city building officials, and others. The ASA stresses the fact that the code is not mandatory, but is intended for municipalities which need it as a basis for setting local standards that are uniform with those used elsewhere in the nation.

Climatic Criteria Defining Efficiency Limits for Certain Industrial Activities: Sec. 4a, Water Supply. *PB 111454, Office of Technical Services, Rm. 6227, Commerce Bldg., Dept. of Commerce, Washington 25, D.C. (1955) 165 pp.; paperbound; $3.00*

This report is part of a more extended study made by the Dept. of Geography of the Univ. of Illinois for the Air Force. Because of its usefulness in determining plant sites for industry, it is being made available to the public. The study treats of the availability and reliability of water in various regions, the need for water by various industrial processes (and ways of stretching the supply), and also the additional requirement imposed by the needs of the workers and even service industries.

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(Continued from page 52 P&R)

The Battle of Seattle has now been won, and it is a pleasure to announce that politics came in second for a change. All the details of the struggle between the city council, led by Councilman Bob Jones as head of its utility committee, and Mayor Allan Pomeroy have not yet come out, but in the rejection of the mayor's strictly political selection for the position of water superintendent in favor of an engineer, we taste a particularly juicy triumph.

The new superintendent, who took office on Mar. 1, is J. Ray Heath, a registered professional engineer in Washington, Oregon, and Alaska, who has practiced engineering for 30 years. A member of AWWA since 1947, Heath is also a member of ASCE and NSPE. He is past president of the Seattle Chapter, Washington Society of Professional Engineers; past president of the Puget Sound Flood Control Council; and a former secretary of the King County Planning Commission. Having served as county engineer for the period 1941–43, he resigned to establish his own practice, first under the name General Engineering Co., Inc., and more recently in the firm of Heath, Hammond, and Collier. Among the projects upon which he has worked have been a number of water supply jobs for Washington water districts, as well as for several municipalities and government installations in Alaska.

Meanwhile, Roy Morse, whom Heath replaces, has stepped into a real job in the other Washington, as the

(Continued on page 88 P&R)

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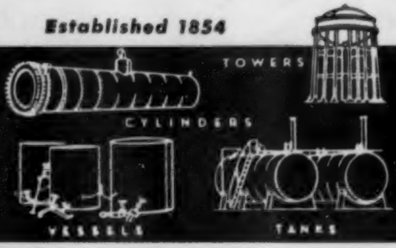

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(*Continued from page 86 P&R*)

director of the Technical Review Staff responsible to the Secretary of the Interior. The Technical Review Staff provides advisory service to the secretary, undersecretary, assistant secretaries, and bureau chiefs on matters which they may refer to it; conducts special studies; provides departmental and interdepartmental liaison; and coordinates the review of planning reports and the participation of representatives on interagency committees dealing with program and policy matters. Roy's staff consists of specialists in the fields of minerals, water, power, public lands, community services, international activities, defense production, and economic and statistical analysis.

All is indeed well that ends this well, though we can imagine that it will be some time before Roy prefers the Potomac to his Puget Sound.

Dorr-Oliver Inc. is relocating its Chicago office in the Merchandise Mart and is opening a new office in the Midland Building in Cleveland. The Chicago office will serve as headquarters of the Central Sanitary Div. and Central Industrial Div., managed, respectively, by O. V. Lindell and R. A. Johnson. The Cleveland office will be staffed by R. R. Denison and J. N. McKenna.

J. D. Kline has been named assistant manager of the Halifax (N.S.) Public Service Commission. Mr. Kline, formerly the commission's chief engineer, is secretary of the Maritime Branch of AWWA's Canadian Section.

(*Continued on page 90 P&R*)

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open smoothly *with* the pressure and close without water hammer. One man can easily remove all operating mechanism for inspection and repair. Stem held in place below hydrant valve means that there is no water loss due to a bent stem.

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offer simplicity of design, trouble-free operation and enduring service. Each is truly a finished product of workmanship. These factors, added to personal experience, tell why progressive water works men have relied on Eddy for generations.

Eddy Hydrants and Valves are available with hub, flange or mechanical joint connections to fit any existing or planned installation.

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WATERFORD, NEW YORK

(Continued from page 88 P&R)

Harold W. Ramey has been named chief engineer for R. H. Baker & Co., Huntington Park, Calif. Mr. Ramey was formerly a consulting engineer for Davis Mfg. Co., Beverly Hills, Calif.

Wilson D. Leggett Jr., Rear Admiral, USN, chief of the Navy's Bureau of Ships, has been appointed vice-president of engineering at American Locomotive Co., Schenectady, N.Y.

A new, multifunction, supervisory control system has been developed by Builders-Providence, Inc., Providence, R.I. Utilizing a single pair of signal wires and supervised by one operator, the "Synchro-Scan" system is said to permit remote control of any combination of pumps, valves, generators, and the like, while also providing two-way multiple-telemetering transmission. The system is designed for simple installation and maintenance by local electricians and station operators.

Robert J. Quinn, chemical engineer and former sales executive of Olin Mathieson Chemical Corp., died Mar. 8 in Tucson, Ariz., at the age of 65. Well known for his work in the chlorine field, Mr. Quinn was long active in the Chlorine Institute, the American Chemical Society, AWWA, and other professional associations.

Patrick Quilty, former New York City commissioner of water supply, gas, and electricity, died at his home on Mar. 12. Eighty-two, Mr. Quilty had been with the department for 35 years before his retirement in 1946.

(Continued on page 92 P&R)

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BIF METERS FEEDERS CONTROLS

Triangle Brand Copper Sulphate

HELPS SOLVE YOUR WATER PROBLEMS

Triangle Brand Copper Sulphate economically controls microscopic organisms in water supply systems. These organisms can be eliminated by treatment of copper sulphate to the surface. Triangle Brand Copper Sulphate is made in large and small crystals for the water treatment field.

Roots and fungus growths in sewage systems are controlled with copper sulphate when added to sewage water without affecting surface trees.

Booklets covering the subject of control of microscopic organisms and root and fungus control will be sent upon request.

PHELPS DODGE REFINING CORPORATION · NICHOLS · TRIANGLE BRAND · CHEMICALS · 40 WALL ST. NEW YORK

PHELPS DODGE REFINING CORPORATION

40 Wall Street, New York 5, N. Y.
230 N. Michigan Ave., Chicago 1, Ill.

(Continued from page 90 P&R)

John H. Murdoch Jr., vice-president and counsel, and Edward A. Geehan, general division manager, American Water Works Service Co., Philadelphia, have been named vice-presidents of the parent firm, the American Water Works Co., Wilmington, Del. Mr. Murdoch has been associated with the organization since 1920, and Mr. Geehan since 1909. Mr. Murdoch, who joined AWWA in 1930 and was made an Honorary Member in 1950, is chairman of the AWWA committee to cooperate with NARUC on proposed water service regulations, as well as of the newly formed AWWA task group to establish a rating scale for water system efficiency.

All cunning and no ham at all is AWWA's most recent exprexy when it comes to public relating. Thus, when he was troubled by a rash of customer complaints of unread meters, he didn't stop at answering them, but went on to attack the cause, developing a comprehensive program to overcome the handicap that Oklahoma City's curb-boxed meters create in convincing customers that the meter reader has really done his work.

First step in the program was to answer all such complaints immediately and without question. By the use of a radio-equipped car, this was worked out so that telephoned complaints are often answered in a matter of a very few minutes—impressing the customer

(Continued on page 96 P&R)

6 Reasons why
WALKING BEAM FLOCULATION
is now specified by water works engineers

1. Eliminates troublesome underwater bearings.
2. Eliminates expensive dry well construction.
3. All bearings accessible for inspection and lubrication.
4. Produces quick responsive floc formation.
5. Longer filter runs.
6. A saving in alum.

Write today for Bulletin 451 and a list of water purification plants that have gone modern.

STUART CORPORATION
N. CHARLES ST., BALTIMORE, MD.

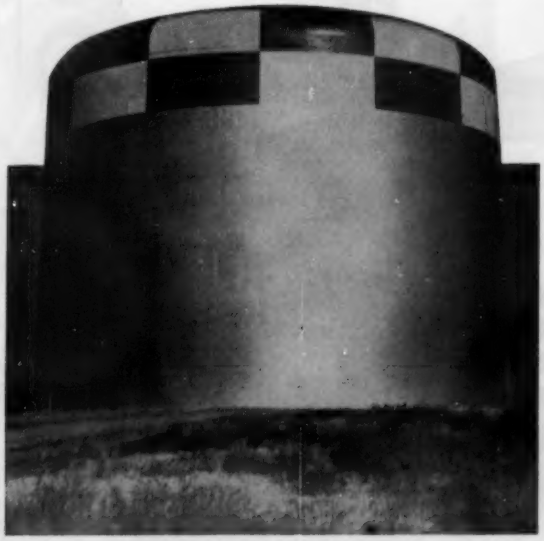
MUNICIPAL SUPPLIES
No 152
ESTABLISHED 1906—47 YEARS OF SERVICE
W.S. DARLEY & Co
CHICAGO 12 ILLINOIS

WRITE TODAY
For
100 PAGE CATALOG
W. S. DARLEY & CO. Chicago 12

Specify "ROSS" AUTOMATIC VALVES

FOLLOW THE LEAD OF THE ENGINEERS WHO SPECIFIED CONTROLS FOR THIS STANDPIPE FOR THE "SOUTH PITTSBURGH WATER CO.," PITTSBURGH, PA.

WATER LEVEL IN THIS "AMERICA'S LARGEST" STANDPIPE IS CONTROLLED BY A 20-inch ROSS DOUBLE ACTING ALTITUDE VALVE.



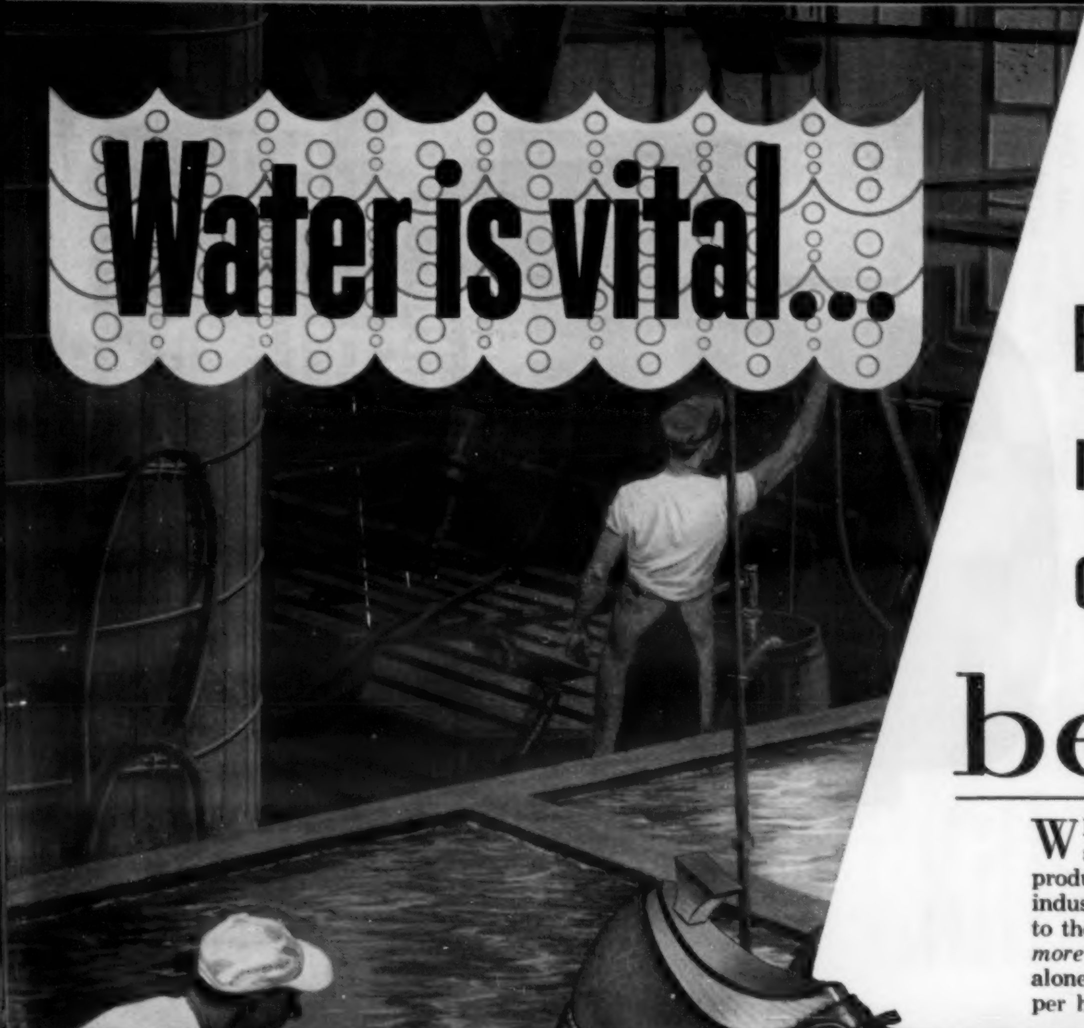
Pioneers in the manufacture of automatic hydraulic control valves. Ross has served the industry since 1879.

— Valves manufactured —

ALTITUDE—BACK PRESSURE—FLOAT PRESSURE REDUCING — SURGE RELIEF — COMBINATION WITH HYDRAULIC AND ELECTRIC PILOT CONTROLS

ROSS VALVE MANUFACTURING CO., INC.

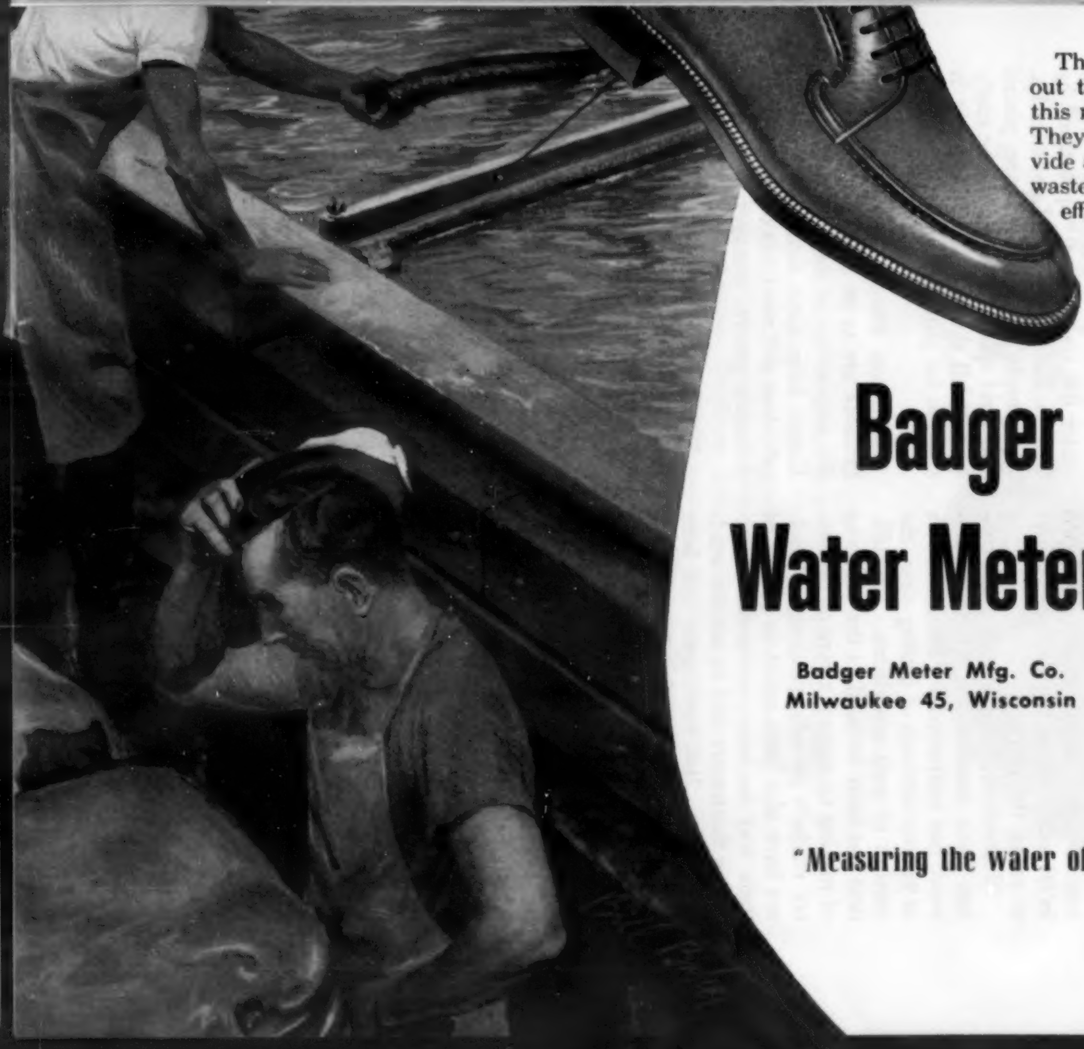
P. O. Box 593 Troy, N. Y.



Badger meters conserve it better!

WITH more than 508-million pairs of shoes purchased last year, leather production is one of America's most vital industries. Yet, from the cleaning of hides to the final finishing of shoes, it takes far *more water than leather* . . . in tanning alone approximately 162 gallons of water per hide.

per hide.



The Badger water meters used throughout the nation help conserve water for this need . . . just as they do for homes. They measure water accurately . . . provide a precise check on water usage and waste . . . make water departments more efficient and self-supporting.

As waterworks men everywhere verify, Badger meters do the job dependably . . . serve through the years with little or no attention.

Badger Water Meters

Badger Meter Mfg. Co.
Milwaukee 45, Wisconsin

"Measuring the water of the world for 50 years"

(*Continued from page 92 P&R*)

with the alertness of the department to his dissatisfaction. When the complainer is at home, the reader answering the call makes the reading in his presence, pointing out the accuracy of the billing basis. If he is not at home, the reader takes a picture of the meter face, using a polaroid camera equipped with infrared-sensitive film and focused to make the picture from a set position inside the meter box. The picture, which is automatically developed in 60 sec, is left at the customer's door to prove the point.

Meanwhile, to approach the problem from another angle, the department has instructed its meter readers in various methods of cutting down the number of such complaints. Friendliness has been stressed as the best way of making customers aware of the meter reader's periodic presence. Readers have also been asked to go out of their way to invite customers to examine the meters and to see the reading made. But cunningest has been the handling of booby traps—those "casual" sticks or stones or, even, pieces of change atop the meter box, those elaborately footprintless surroundings, or some of the other sleuthful contrivances intended to detect whether the meterman actually did call. Reversing a previous policy which insisted that the things be left *exactly* as found, the department now asks metermen deliberately to spring all traps and generally to make their calls obvious if not obnoxious.

A lessison from Morrison this is—Cunningham, that is.

Packaged water treatment is offered for small communities, camps, industrial plants, etc., by Infilco Inc., Tucson, Ariz. The "Accelapak" treatment plant is said to require charging of the chemical feeders only once a day. The plant is interlocked electrically to start and stop from a float switch in the clear well, thus reducing attendance time to a minimum. Capacities range from 15 to 250 gpm or more.

A specific-gravity indicator said to provide rapid and accurate determination of liquid density is being marketed under the trade name "Spee/Gee" by Brooks Rotameter Co., Lansdale, Pa. A "nonspin" hydrometer is so placed that fluid specific gravity can be easily read at all times. The instrument is suitable for panel mounting.

Johnston Pump Co. services and facilities are to be expanded following the acquisition of the firm's assets by Emsco Mfg. Co. A. H. Miller, vice-president of Emsco, has been appointed Johnston general manager.

William C. Sandland has been appointed Reilly Tar & Chemical Corp. sales representative for the Houston area.

Willing Water has at last been called to Washington—officially, that is—to give the water word to Congressmen. It was the staff of the Legislative Reference Service of the Library of Congress which issued the official invitation through a request for 20 copies of Willie's booklet, *The Story of Water Supply,* "for members of Congress." A little disappointed that he wasn't asked for a full 531, Willie is biding his time until the sessions start again after the Easter recess. Once the speeches begin, 20 copies aren't going to be nearly enough, nor 16 pages nearly long enough. But Willie will, at least, be on tap.

here's what "out of sight out of mind" does to a water main

"Out of sight—out of mind" can be a mighty expensive philosophy in any water distribution system. The above unretouched photograph proves this point. It shows a badly tuberculated *eight inch* main whose *inside diameter was reduced to an average of almost 4.5 inches.* Resultant higher pumping costs with reduced pressure and carrying capacity make it costly to tolerate such conditions. That is why the savings effected in reduced pumping costs frequently pay for the *low cost* of National water main cleaning.

Since there's never a charge or obligation to inspect your mains, *call National now!*

Call in National today!

NATIONAL WATER MAIN CLEANING COMPANY

50 Church Street • New York, N. Y.

ATLANTA, GA; 333 Candler Building • BERKELEY, CALIF; 905 Grayson Street • DECATUR, GA; P. O. Box 385 • BOSTON, MASS; 115 Peterboro Street • CHICAGO; 122 So. Michigan Avenue • ERIE, PA; 439 E. 6th Street • FLANDREAU, S.D; 315 N. Crescent Street • KANSAS CITY, MO; 406 Merchandise Mart and 2201 Grand Avenue • LITTLE FALLS, N.J; BOX 91 • LOS ANGELES; 5075 Santa Fe Avenue • MINNEAPOLIS, MINN; 200 Lumber Exchange Building • RICHMOND, VA; 210 E. Franklin Street • SALT LAKE CITY; 149–151 W. Second South Street • SIGNAL MOUNTAIN, TENNESSEE; 204 Slayton Street • MONTREAL, CANADA; 2032 Union Avenue • WINNIPEG, CANADA; 576 Wall Street • HAVANA, CUBA; Lawrence H. Daniels, P. O. Box 531 • SAN JUAN, PUERTO RICO; Luis F. Caratini, Apartado 2184.

DRILL WITH SPINKS

FOR HIGHER CAPACITY WELLS

SPECIAL MUDS MINED AND PROCESSED FOR WATER WELL DRILLING!

- **SPINKS Gleason**—easy-mixing mud, washes out quickly, easily. Minimum penetration! Makes heavy mud — 9.5-lb. to 10-lb. range — stops cave-ins! Excellent lubrication properties! Removes cuttings quickly, thoroughly! Durably sacked in water-repellent asphalt lined bags! 50-lb. size for easy handling . . . less chance of loss!
- **SPINK-Gel** — high-yielding, finest quality Wyoming bentonite. Low water loss! Exceptional lubricating qualities!
- **SPINK-O** — medium weight mud. Combines outstanding qualities of Gleason and Spink-Gel.

Distributorships now open in several choice territories! WRITE, WIRE or CALL Rich Carothers. Telephone 1502, Paris, Tenn.

H. C. SPINKS CLAY COMPANY, INC.
Mines and General Offices
Paris, Tennessee

Spinks

Service Lines

An equipment and instrumentation checklist for water works engineers is available from B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I. The 4-page booklet, Technical Memo B-I-F M3, is illustrated with photographic flow diagrams.

Tapping prestressed concrete steel cylinder pipe is described in a 12-page booklet issued by Price Brothers Co., Box 825, Dayton 1, Ohio.

Steam contamination, its dangers and prevention, is the subject of a 6-page folder, "Steam Purity," available from Hall Labs., Inc., 323—4th Ave., Pittsburgh 22, Pa.

Punchcard billing and accounting devices are briefly described in a 6-page catalog (TM 930) issued by Remington Rand Inc., 315—4th Ave., New York 10, N.Y. The complete line of the company's punchcard machines is covered.

Steel detachable chain specifications, production, and application theory are dealt with in a 64-page booklet published by Chain Belt Co., under the title "Rex Agricultural Implement Chains." Requests for copies of the bulletin, No. 54-54, should be sent to the company, Dept. PR, Milwaukee 1, Wis.

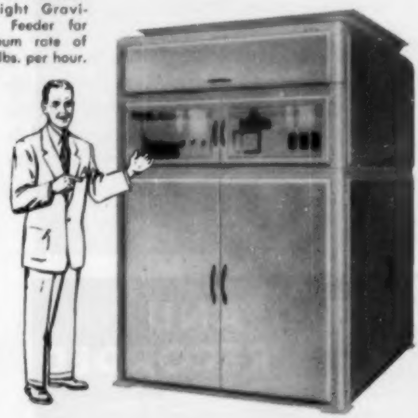
Meter setting and testing equipment is described in a handsomely bound (looseleaf), tab-indexed, 120-page catalog (No. 56) issued by Ford Meter Box Co., Inc., Wabash, Ind. The publication also includes information on such matters as how to make good meter settings, prevent freezing, and select testing machines.

(*Continued on page 100 P&R*)

Model GLW-0 Loss-in-Weight Gravimetric Feeder for maximum rate of 100 lbs. per hour.

Model GLW-1 Loss-in-Weight Gravimetric Feeder for maximum rate of 1,000 lbs. per hour.

Model GLW-2 Loss-in-Weight Gravimetric Feeder for maximum rate of 4,000 lbs. per hour.



When only the BEST is good enough . . .

don't shop for bargains

What does the super-accuracy of Omega Loss-In-Weight Gravimetric Feeders really mean to the modern water works? To some plants, these feeders mean economy . . . the last word in the control and conservation of costly water treating chemicals. Others pick Omega Loss-In-Weight Feeders for safety, knowing that these flood-proof feeders provide positive control of critical chemicals. Still others select Omega Loss-In-Weight Feeders for flexibility, to meet a wide range of raw water conditions and seasonal water demands.

If you are considering up-grading your chemical feeding equipment, or installing additional feeding capacity, investigate these and other advantages of Omega Loss-In-Weight Gravimetric Feeders . . . then you'll agree that only the best is good enough. Bulletins 30-H12A and 30-K4 give complete details — send for your copies today. Omega Machine Co., 365 Harris Av., Prov. 1, R. I.

OMEGA *THE LAST WORD IN* **FEEDERS**

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • BUILDERS-PROVIDENCE, INC.

METERS FEEDERS CONTROLS

Service Lines

(Continued from page 98 P&R)

Water conditioning and waste treatment equipment is covered in a 4-page bulletin (No. WC-117) available from Graver Water Conditioning Co., 216 West 14th St., New York 11, N.Y.

Construction features of Allis-Chalmers open type vertical hollow shaft motors for outdoor service, 2–125 hp, are described in Bul. 51B7900. The motors are available with self-release coupling, ball type nonreversing clutch, or rigid coupling, or without coupling. The 6-page bulletin may be obtained from Allis-Chalmers Mfg. Co., 1026 South 70th St., Milwaukee, Wis.

Minneapolis-Honeywell announces the following recent publications: Data Sheet 10.3–4a, Brown float-actuated flow and liquid level meter; Bul. 1120, pneumatic control and transmission systems (including data on operating practice); Bul. 8410, "Tel-O-Set" automatic ratio relay; Bul. 8506, electric industrial motorized valve assemblies; Catalog 5002, a composite catalog of industrial instruments and equipment; and Specification Sheet 602, integral cam programer thermometers. Requests, including identification number of publication desired, should be addressed to Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa.

Single-stage steam turbines with steel casing construction are described, with charts and photographs, in Bul. 1954C, available from Worthington Corp., Advertising & Sales Promotion Dept., Harrison, N.J.

(Continued on page 102 P&R)

Each length of pipe we manufacture passes through the above hydrostatic test press where it is filled with water and the pressure raised to 500 pounds per square inch. The most common water works pipe is designed for an operating pressure of 150 pounds per square inch. This undergoes the 500 pounds per square inch hydrostatic test and permanent records for each piece of pipe are kept on file for inspection by our customers at all times. You can be assured with Alabama's Super De Lavaud Cast Iron Pipe. In sizes of 3" to 24" in modern long lengths. Bell and Spigot, Mechanical Joint and Flanged Pipe.

General Sales Offices
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ALABAMA PIPE COMPANY
ANNISTON ALABAMA

Atlanta engineers, Wiedeman and Singleton, again specify INERTOL® PAINTS

Pump room and part of main operating floor—Water Works, Griffin, Georgia

Economical protection from abrasion, submersion, condensation and humidity is achieved here with colorful, durable Inertol coatings: Glamortex® takes hard knocks; Torex® is *made* for submersion; Ramuc® Utility withstands condensation and an average 75% humidity during the winter.

• Noted for the production of turkish towels, velvets and paper boxes, Griffin, Georgia, also claims one of the best-kept water works in the South. Wiedeman and Singleton are the consulting engineers on the job, and they have been specifying Inertol coatings ever since 1939. They know Inertol coatings are versatile and resistant… each coating meeting rigid specifications of hardness, elasticity and chemical inertness as well as providing lasting beauty.

Every water works coating you select from the Inertol line has been developed for a particular purpose. Each has had its superiority proved in hundreds of installations throughout the country. Our Field Technicians will welcome the opportunity to discuss the Inertol line fully with you at your office. Or write today for the "Painting Guide"—an invaluable aid for Design Engineers, Specification Writers and Plant Superintendents.

Inquire about Rustarmor®, Inertol's new hygroscopically-controlled rust neutralizing paint.

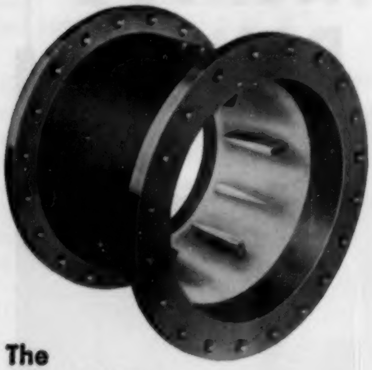
INERTOL CO., INC.

INERTOL PROTECTION MEANS LOWER MAINTENANCE COSTS

484 Frelinghuysen Avenue
Newark 5, New Jersey

27 G South Park
San Francisco 7, California

FOR *LOWEST* HEAD LOSS IN FLUID METERING



The *Gentile** FLOW TUBE

*GEN-TIL'-LY

WHERE HEAD LOSS IS IMPORTANT...The Gentile Flow Tube can be designed to produce a measurable differential with lowest permanent pressure loss of *any* head meter.

ACCURACY...Differential is produced from points of equal cross-sectional area. Furnished with head capacity curves, and guaranteed for exceptional accuracy when used with any standard indicating, recording or integrating meter.

REVERSIBILITY...When the flow is reversed, the differential is reversed. Permits metering reverse flow at lowest possible equipment cost.

LOW INSTALLED COST...Average length is only 1½ times the pipe diameter, and straight runs entering and following are not required unless installed near throttling valves or regulators.

Write for Bulletin FT-101 or specific recommendations.

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE UNION, N. J.

AUTOMATIC VALVES
SAFETY VALVES • FLOW TUBES

Service Lines

(Continued from page 100 P&R)

Impressed-current "Duriron" anodes for cathodic protection are described in Bul. DA/1. The 8-page bulletin incorporates data on the properties and applications of these high-silicon cast-iron anodes. Address requests to Duriron Co., Inc., Dayton, Ohio.

Pipe detector operation is discussed in an 8-page manual issued by Detectron Corp. Although written for the company's Model 505, it contains information said to be applicable to other makes. The manual is available from the company at 5528 Vineland Ave., North Hollywood, Calif.

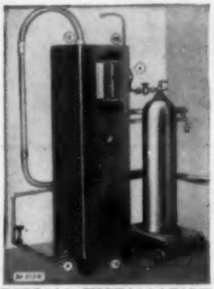
A structural-steel stock list (8 pages) is available from Structural Steel & Forge Co., 545 West 7th South St., Salt Lake City 10, Utah.

"Chlor-O-Mite" low-capacity chemical feeders and their applications are described in a 2-page bulletin (No. 1910–3) offered by Proportioneers, Inc., a division of B-I-F Industries, Inc. Designed for controlled feeding of hypochlorite or other water treatment solutions, the unit comes in two models, hydraulically operated or diaphragm type. The bulletin can be obtained from Proportioneers, Inc., 345 Harris Ave., Providence 1, R.I.

Sight flow indicators, transparent or reflex, which can be installed on new or existing ½–2-in. pipelines are described in a data sheet (Unit No. 253) issued by Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

The "Dehydrafilter," a compressed-air dehydrator, is covered in a 2-page bulletin (C-5154) of Hankison Corp. Designed for small volumes of compressed air serving liquid level indicators, purge assemblies, and remote-control installations, the unit comes in three models. The bulletin is available from the company at 412 Biltmore Bldg., 951 Banksville Rd., Pittsburgh 16, Pa.

CHLORINE GAS CONTROL EQUIPMENT



TYPICAL INSTALLATION SHOWING SCALE

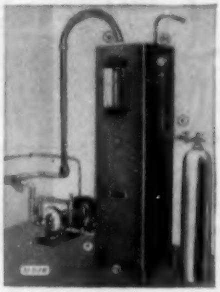
SterElatorS by Everson

METER AND CONTROL CHLORINE GAS IN THE NON-CORROSIVE STATE

RATIOS 10 TO 1—50 TO 1—110 TO 1

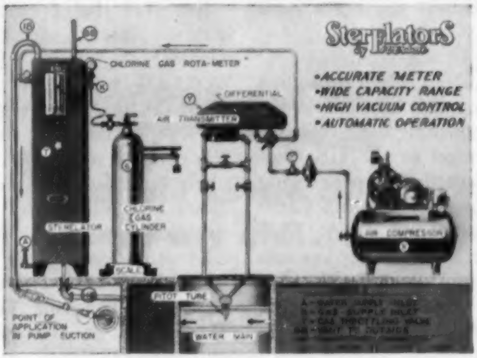
VISIBLE FLOW INDICATION FOR

WATER WORKS
SEWAGE TREATMENT
INDUSTRIAL PLANTS
SWIMMING POOLS



TYPICAL INSTALLATION WITH BOOSTER PUMP ON WATER SUPPLY

EASY TO OPERATE



LOW MAIN-TENANCE COSTS

THE EVERSON AIR-O-MATIC SYSTEM

AUTOMATIC PROPORTIONING GAS FEED TO LIQUID FLOW

HIGH CAPACITY R636

HIGH VACUUM
SOLUTION FEED
DEPENDABLE
ECONOMICAL

OPEN FRAME MODEL B682

Everson Manufacturing Corporation

221 W. Huron Street Chicago, 10, Illinois

REPRESENTATIVES IN PRINCIPAL CITIES

Section Meetings

Southeastern Section: The 26th annual conference of the Southeastern Section was held on Mar. 20–23, 1955, at the Hotel DeSoto, Savannah, Ga. Total registration was 325, a record for the section. Included in this number were 65 ladies, 123 sales representatives, and 137 water works personnel, engineers, and guests.

The first session of the technical program was devoted to the drought of 1954 and its effects upon water supplies in the area. On Monday morning M. T. Thomson and A. E. Johnson of the US Geological Survey presented data concerning stream flows in Georgia and South Carolina; W. B. Williams and T. A. Kolb described conditions at the water systems most seriously affected; and B. M. Hall Jr. summarized the situation, listing things municipalities could do to prepare for future droughts.

Tuesday morning's program featured talks by Clair P. Guess Jr., South Carolina Soil Conservation Commission, on "Water Control Policies"; by A. O. Putnam, Layne & Bowler Co., on "An Opportunity for Your Water Department"; and by Frank C. Amsbary Jr. on "The Teays Valley."

Tuesday afternoon R. R. Adams, Cons. Engr., presented data covering 7 years' operation of the Savannah water treatment plant; A. B. Middleton, Pennsylvania Quartz Co., described the latest developments in the use of activated silica; and A. E. Griffin, Wallace & Tiernan Inc., discussed "Modern Concepts in Water Treatment."

The theme of Wednesday's program was "Ground Water in the Coastal Plains of Georgia and South Carolina." The picture "Deep Waters" was shown by Allen Sickel, Layne-Atlantic Co., after which R. L. Wait, G. E. Siple, and M. A. Warren, all of the US Geological Survey, gave a thorough coverage of geology and water resources of the area. The final paper on the program, presented by Frank Mascitti, dealt with "Automatic Control Systems Applied to Water Works."

At the business meeting, Tuesday noon, Bruce J. Sams was elected chairman for the coming year; Carl C. Lanford, vice-chairman; John R. Bettis, trustee from South Carolina; and Sherman Russell, national director. L. E. Wallis continues as trustee from Georgia, and N. M. deJarnette as secretary-treasurer.

At the banquet, Tuesday evening, a plaque and gavel were presented to the retiring chairman, W. C. Bowen, in recognition of his services to the section. Frank C. Amsbary Jr., national vice-president, presented life membership certificates to Guy C. White and H. F. Wiedeman, and 25-year membership pins to R. G. Hicklin, Paul Weir, and Francis B. McDowell Jr. A life membership certificate was awarded to Frank W. Chapman in absentia, as was a 25-year pin to B. B. Meng Sr. John F. Pearson, Mgr., Public Utilities, Orangeburg, S.C., was nominated to receive the George Warren Fuller Award.

The visiting ladies were conducted on two tours of the scenic and historic spots in and around Savannah and taken to a luncheon at the famous Pirate's House. Club Room entertainment, provided each evening by the manufacturer members,

(Continued on page 106 P&R)

the tale of two cities
—one city did . . . one city did not!

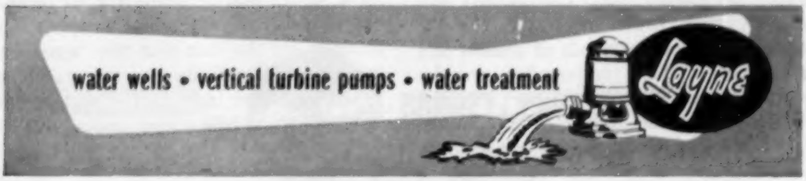
The city fathers of "the city that did" blueprinted the future. With the help of "the man from Layne" they projected industrial and population growth into the future and kept water supply ahead of demand. The result? . . . continued progress . . . accelerated prosperity, for growth depends upon water supply.

On any question that relates to water, wise civic planners "ask the man from Layne."

LAYNE & BOWLER, INC.

Memphis 8, Tennessee

Layne Associate Companies Throughout the World



Section Meetings

(*Continued from page 104 P&R*)

afforded an occasion for fun and fellowship and featured an excellent program of organ music by Mrs. Jack Greenlees. Many members took Monday afternoon to inspect one or more of the facilities opened to the group—the Savannah Water Works, the Savannah Sugar Refinery, the Union Bag Co., and the State Port.

The warm hospitality of the local people, especially in entertaining the visiting ladies; the good technical program; the informal fellowship which prevailed; and the color of Savannah's springtime flowers, all had a part in making this one of the Southeastern Section's better meetings.

N. M. DEJARNETTE
Secretary-Treasurer

Indiana Section: The 47th annual Indiana Section meeting, at the Lincoln Hotel, Indianapolis, got under way promptly at 1:45 PM on Feb. 9, 1955, when Chairman Harry J. Draves called for order and gave a brief address of welcome to the 475 (including 81 ladies) who attended—a new record. The technical session followed immediately, with Charles H. Bechert, Director, Water Resources Div., Indiana Conservation Dept., Indianapolis, presenting a paper on the drought and water shortages in Indiana. Mr. Bechert compared the below-average rainfall over the last 3 years with the precipitation pattern over the past 70 years in the state. In the past no periods of below-normal rainfall have exceeded 3 years' duration, and he stated that he hopes 1955 does not deviate from this pattern. He also forecast new water shortages in the future as our population increases and our living standards require greater per capita use. He pointed out, however, that sufficient water can be obtained to meet the needs of almost any community if those responsible are determined to go after it. Water shortage experiences in the towns of Bloomington, Ferdinand, and Milan were discussed, respectively, by J. M. Cason, City Engr., Bloomington; Carl J. Heim, Cons. Engr., Jasper; and T. W. Thompson, Town Board Member, Milan. Each told of the extensive water use restrictions necessary in the past to conserve the supplies available and described what was being done or considered to prevent this situation from arising in the future. In each case, the question of financing was paramount; the smaller the community, the more difficulty it posed.

Howard E. Degler, Tech. Director, Marley Co., Kansas City, Mo., spoke on methods for the reuse of cooling water. He mentioned the increased use of water as a result of the great strides made by the air-conditioning industry. By a series of slides he showed different styles and capacities of cooling towers manufactured by his company. Each required about 1 per cent makeup for the amount of water being circulated, according to Mr. Degler.

The buffet sports supper held Wednesday evening was highly entertaining. Warren Whitney, Vice-Pres., James B. Clow & Sons, acted as master of ceremonies. The highlight of the evening was a talk by Terry Brennan, Head Football Coach, Notre Dame University. Coach Brennan summarized the successes of the team during the past season and also related some of the humorous incidents that had occurred during his tenure.

On Thursday morning two concurrent sessions were held. In the surface water section, Robert W. Schmidt, Chemist, South Dist. Filtration Plant, Chicago, used slides to illustrate the type of equipment which can be employed to measure the radioactivity of water supplies. He brought out the fact that the "emergency level" of radioactivity in water can be detected by rather inexpensive portable field instruments, while other, more sensitive

(*Continued on page 108 P&R*)

Electrical "Hawkshaw"

Detecting "holidays" is the task of this electrical inspection apparatus. In the new 56-inch Bull Run water pipeline for Portland, Ore., less than one holiday for every hundred feet of pipe was found—an almost perfect job.

Nine thousand gallons of Barrett waterworks primer, 2300 tons of Barrett waterworks enamel and 2,300,000 sq. ft. of Barrett tarred asbestos felt protect the Portland pipeline inside and out.

Barrett Waterworks Enamel is easy to apply and provides long-lasting protection for costly pipes. This superior coating is of the highest quality and meets all A.W.W.A. standards. To assure longer service for your pipe, at a minimum cost, specify Barrett.

It offers 10 definite advantages:

• *Rigid quality control* • *Prevents tuberculation and incrustation of interior pipe surfaces* • *Effectively protects external pipe surfaces against corrosion* • *High dielectric properties* • *Impermeable to moisture, non-absorptive, non-porous* • *High ductility and flexibility, high resistance to soil stresses* • *Unusual tenacity* • *Effective under all kinds of climatic conditions and topography* • *Quick service* • *Wide availability*

BARRETT DIVISION, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y. In Canada: The Barrett Company, Ltd., 5551 St. Hubert St., Montreal

Allied Chemical

Visit us at booth 38
AWWA Convention
Chicago, June 12 to 17

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Section Meetings

(Continued from page 106 P&R)

and more expensive, equipment is required for low-level work.

A paper prepared by Joseph C. Filicky, Research Chemist, West Virginia Pulp & Paper Co., Tyrone, Pa., was delivered by E. A. Sigworth, Chemist & Technician, of the same company. The paper dealt with some of the taste and odor control problems experienced by the company in Indiana. Mr. Filicky stated that, with the proper usage of a suitable activated carbon, any taste and odor condition can be satisfactorily controlled. He cited the case histories of six plants in which the threshold odors of highly polluted supplies were controlled to produce a palatable water through the use of activated carbon. A discussion of the paper was contributed by A. E. Griffin, Consultant, Div. of Technical Services, Wallace & Tiernan Inc., Belleville, N.J. Mr. Griffin spoke principally on the taste and odor treatment chemicals classed as oxidants—oxygen (aeration), chlorine, chlorine dioxide, and ozone. He emphasized that chlorine occupies a unique place in the taste and odor control picture: although it is used primarily for disinfection, it also results in many other benefits automatically. The operator should be familiar with the various types of chlorine residuals, however, and should know how they react under varying conditions.

In the ground water session on Thursday morning, John B. Patton, Prin. Geologist, Geological Survey, Indiana Dept. of Conservation, Bloomington, used slides to illustrate the geological makeup of the state. According to Mr. Patton, ground water is more likely to be available in the northern two-thirds of Indiana, owing to glaciation. An intelligent appraisal of the possibilities of obtaining adequate underground supplies may save the needless expense of drilling for ground water in areas where it is generally lacking or of constructing more expensive surface reservoirs in areas where the likelihood of obtaining ground water is good. J. B. Wilson, Cons. Engr., Indianapolis, emphasized the importance of a careful geological survey by a competent engineer when searching for a new or supplemental water supply. He mentioned seven communities in the southern portion of the state that had drilled wells close to town or to existing facilities in the vain hope of reducing pipeline costs. Mr. Wilson stated: "Since water is not where you drill but where you find it, each case represented frustration and extra costs without any results."

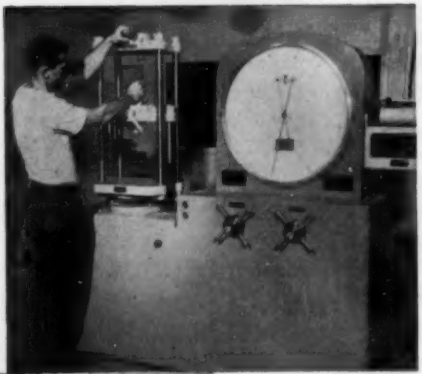
A discussion on reverse-circulation drilling was presented by N. E. Gunderson, Pres., Layne-Northern Co., Inc., Mishawaka, Ind. A comparison of the hydraulic conditions necessary for reverse-circulation and artesian recharge well drilling was made. The differences between rotary drilling and reverse-circulation drilling, with regard to drilling speeds, drill action, size and removal of cuttings, and size and cost of equipment necessary, were also given. Mr. Gunderson made a general statement recommending the use of reverse-circulation drilling for water wells in the glacial drift which require holes over 20 in. in diameter.

Following the noon luncheon, the business meeting was held. The committee chairmen gave progress reports. The nominating committee asked permission to report later as it had been unable to meet, owing to the late arrival of some members. A unanimous resolution was passed requesting the Section Secretary to express the regrets of the Indiana Section that President Maffitt was unable to attend because of illness, and to wish him a speedy recovery.

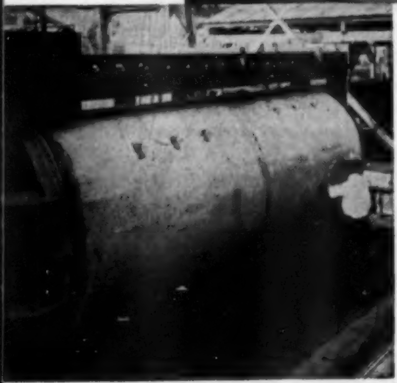
The Thursday afternoon session was opened by William W. Aultman, Engr., Alvord, Burdick & Howson, Chicago, who presented a paper prepared by himself and Louis R. Howson of the same

(Continued on page 110 P&R)

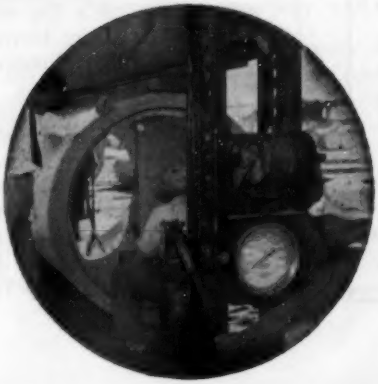
Standard 6"x12" test cylinders are made from the same batch of concrete as the pipe, cured with the pipe in the same steam box and are subjected to compression tests.



Steel reinforcement rods are tested to determine their physical properties. Stress-strain diagram may be plotted on recorder at right.



Completed pipe sections receiving hydrostatic test. Water pressure is increased until ultimate failure of the pipe section; research engineer makes periodic examinations as pressure goes up.



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Section Meetings

(Continued from page 108 P&R)

firm. The paper discussed some of the current trends in water treatment plant design and covered such items as intakes, mixing and coagulation, sedimentation, sludge removal equipment, suspended-solids contact basins, filters, softening, and lime reclamation. Mr. Aultman illustrated his points by mentioning several specific installations. A discussion of this paper, with special emphasis on suspended-solids contact softeners and clarifiers, was presented by William U. Gallaher, Plant Supt., Water Dept., Appleton, Wis. He mentioned several of the different types offered and showed the design of a few of them with slides. According to Gallaher, it has been concluded that the Appleton water softening plant can be operated more satisfactorily with the conventional system than with the suspended-solids contact system during periods when the water being treated has a high temperature and a large algae population and receives heavy dosages of carbon. At other times the suspended-solids contact softeners appear more desirable than the conventional type.

David J. Ford, Asst. Sales Mgr., Ford Meter Box Co., Wabash, Ind., concluded the afternoon program with a paper titled "Equipment and Layout of Meter Maintenance Shop" (this paper was published in the June 1954 JOURNAL).

The Thursday night banquet and the Manufacturers' Club Room both enjoyed capacity attendance. The nominating committee report was accepted and the following were elected: national director —Clyde E. Williams, Cons. Engr., South Bend; chairman—George G. Fassnacht, State Board of Health, Indianapolis; vice-chairman—Everitt Robbins, Supt., Speedway Water Works; secretary-treasurer—Robert J. Becker, Indianapolis Water Co. Certificates were awarded those who had attended a 4-day short course at Purdue University by Prof. Harvey Wilke. The Joseph F. Bradley Award, for membership gain and district meeting attendance, was presented to the Northeast Area. William W. Mathews was announced as an AWWA Life Member. Charles H. Bechert received a large ovation when he was nominated for the George Warren Fuller Award.

The final session on Friday morning got under way with a film showing the highlights of the Purdue University football season. Then E. J. Zimmer, Director, Chicago Plumbing Testing Lab., described several ways in which back siphonage can contaminate drinking water systems. As a result of the laboratory's research, a ten-point program has been developed with regard to plumbing as a whole and emphasizing water supply.

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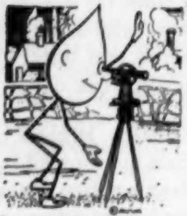
Secretary-Treasurer



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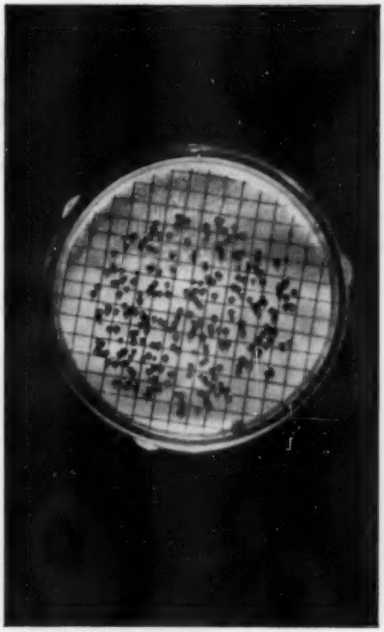

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CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received Mar. 1–31, 1955

Adams, Charles MacLain, Engr., American Pape & Constr. Co., Box 3428 Terminal Annex, Los Angeles 54, Calif. (Jan. '55) *RD*

Akron, Village of, Munic. Water, Almer R. White, Supt., Public Works, Box 128, Akron, N.Y. (Munic. Sv. Sub. Jan. '55) *MPD*

Aldrich, Robert D., Supt. of Public Works, Village of Fridley, 6431 University, Minneapolis 21, Minn. (Jan. '55) *M*

Avery, E. F., Supt., Water & Sewage, Manchester, Ga. (Jan. '55) *MPD*

Azcarate, Juan Cayo, Eng. Inspector, Ministerio de Fomento, Ave. Principal da Castellana 110, Caracas, Venezuela (Jan. '55) *RP*

Baker, Russell, Chief Operator, Anna State Hospital, Anna, Ill. (Jan. '55) *MP*

Baldwin, Thane H., Jr., Civ. Engr., Box 618, Basin, Wyo. (Jan. '55) *RP*

Beacham, Robert M., Supt., Public Works, Anson Ave., Laurinburg N.C. (Jan. '55)

Bekkala, Ronald R., Sr. Asst. Civ. Engr., Dept. of Water Supply, Detroit, Mich. (Jan. '55)

Berry, Howard A., Supt., Water & Elec. Plant, 149 E. 3rd St., Carthage, Mo. (Jan. '55) *MRPD*

Blank, Arthur S., Chemist, Modern Swimming Pool Co., 1 Holland Ave., White Plains, N.Y. (Jan. '55) *P*

Blue, Cy., Pres., Cy Blue Plumbing Co., 5758 Hollywood Blvd., Sarasota, Fla. (Jan. '55) *P*

Bradney, Leland, City Chemist, City Engr.'s Office, Sioux Falls, S.D. (Jan. '55) *P*

Brandell, Clarence W., Sales Engr., Wallace & Tiernan Inc., 8779 Grand River, Detroit 4, Mich. (Jan. '55) *P*

Breard, Charles E., Professional Technician, Breard Chem. Div., Brooks Chems. Inc., 335 E. St. Joseph St., Quebec City, Que. (Jan. '55) *MRPD*

Byers, C. A., Salesman, Diamond Alkali Co., 1323 Oliver Bldg., Pittsburgh 22, Pa. (Jan. '55)

Camp, John M., Water Supt., Munic. Water Works, New Castle, Tex. (Jan. '55) *PD*

Carroll, Francis P., Asst. Secy., Elizabethtown Water Co. Consolidated, 22 W. Jersey St., Elizabeth, N.J. (Jan. '55) *M*

Casa Services, Inc., L. O. Zimmerman, Pres., Box 98, Shalimar, Fla. (Corp. M. Jan. '55) *MRPD*

Christian, W. C., Pres., Greensboro Water Co., Greensboro, Ala. (Apr. '55)

Colby, Alan B., Cons. Civ. Engr., Munic. Water Supply & Distr., Box 197, Comex, B.C. (Apr. '55) *RD*

Connelly, Hugh H., Asst. Supt. of Utilities, Newberry, S.C. (Jan. '55)

Cosulich, William F., Graduate Student, Massachusetts Inst. of Technology, 1167 Boylston St., Boston 15, Mass. (Jr. M. Jan. '55) *P*

Coulter, Milton D., Supt., Com. of Public Works, 228 Allen St., Mayville, Wis. (Jan. '55)

Coupe, William A., Water Supervisor, Ridge Rd., North Arlington, N.J. (Jan. '55)

Cowlitz County Public Utility Dist. No. 1, O. G. Hittle, Mgr., 1421—14th Ave., Longview, Wash. (Corp. M. Jan. '55) *M*

Crandell, George B.; *see* Meridian Township (Mich.) Water Dist. No. 1

Crow, J. T., Plant Mgr., Schwartz Co., Inc., Box 1702, El Paso, Tex. (Jan. '55) *P*

Cuero Water Dept., W. E. Harwood, Supt. of Public Works, 208 S. Esplanade St., Cuero, Tex. (Corp. M. Jan. '55) *M*

Dallas, City of, Lynn H. McCulley, Auditor, Box 67, Dallas, Ore. (Munc. Sv. Sub. Jan. '55) *MD*

Davies, J. Wynne; *see* Orillia (Ont.) Water, Light & Power Com.

Davis, Carl H., Dist. Mgr., Water Works, Florida Utilities Corp., Box 346, Lake Wales, Fla. (Jan. '55) *MPD*

Decker, William Charles, Jr., Sales Engr., B-I-F Pacific Inc., Box 244, Oanville, Calif. (Jan. '55) *MRPD*

DeMartini, Dewey, Maint. Supt., Contra Costa County Water Works Dist. No. 1, Box 402, Brentwood, Calif. (Jan. '55) *MD*

Denson, Frederick G., Engr., Eng. Dept., Water Works & Sewerage Branch, Winnipeg, Man. (Jan. '55) *M*

Diehl, F. D.; *see* McPherson (Kan.) Water & Elec. Dept.

Dooge, James C. I., Graduate Student, College of Eng., State Univ. of Iowa, Iowa City, Iowa (Jr. M. Jan. '55) *P*

Dorman, L., Supt., Water & Elec. Board, Box 123, Elba, Ala. (Jan. '55) *M*

Drye, Rohn F., Jr., Haws & Drye & Assocs., Wallace Bldg., Little Rock, Ark. (Jan. '55)

Duff, E. Roy, Field Engr., Fischer & Porter Co., Box 2715, Cincinnati 37, Ohio (Jan. '55) *PD*

El-Naggar, A. Sami, Graduate Student, Purdue Univ., Box 642, West Lafayette, Ind. (Jr. M. Jan. '55) *PD*

Eshelman, Joseph W., Jr., Sales Engr., Joseph W. Eshelman & Co. Inc., 1812—28th Ave. S., Birmingham 9, Ala. (Jan. '55) *D*

Eubank, J. I., Mgr., Chambers County Water Control & Irrigation Dist. No. 1, Box 727, Mont Belview, Tex. (Jan. '55) *M*

Evans, J. Dwight; *see* Steel Plate Fabricators Assn.

Fairfax, Town of, Irvin H. Mason, Town Engr., 101 Mechanic St., Fairfax, Va. (Corp. M. Jan. '55) *MRD*

Filippone, Francis S., Secy-Treas., Zane-Filippone Co., 19 Northfield Ave., West Orange, N.J. (Jan. '55) *RP*

Folsom, V. L., Supt., Water Works, Box 11, Perry, Fla. (Affil. Jan. '55)

Fortner, Carl, Dist. Mgr., California Water Service Co., 4492 Whittier Blvd., Los Angeles 22, Calif. (Jan. '55) *M*

Foster, E. B., Owner, Weldit Tank & Steel Co., 2828 Broadway, Bellingham, Wash. (Jan. '55) *MRPD*

Francois, Frederic S., 2nd Vice-Pres., Pontusco Corp. of Cuba, El Cotorro, Havana, Cuba (Jan. '55) *D*

Frederick, J. T., Plant Supt., Lafourche Parish Water Dist. No. 1, Lockport, La. (Jan. '55) *MP*

Garlepy, Yvon; *see* St. Laurent (Que.)

Garland, J. J., Div. Mgr., American Water Works Service Co., Inc., 14½ N. 10th St., Richmond, Ind. (Jan. '55) *M*

Garland, City of, L. E. Stark, City Mgr., Box 126, Garland, Tex. (Corp. M. Jan. '55) *MD*

Gaskill, Harold L., Mgr., Industrial Chems., Ideal Chem. & Supply Co., 1301 Heistan Ave., Memphis, Tenn. (Jan. '55) *P*

Gates, Charles D., Prof., San. Eng., School of Civ. Eng., Cornell Univ., Ithaca, N.Y. (Jan. '55) *P*

Gellon, Edmundo R., Chief Director, Studies & New Projects, Obras Sanitarias de la Nacion, Calle Charcas 1840, Buenos Aires, Argentina (Jan. '55) *PD*

Hall, Clark J., Jr., Field Engr., Fischer & Porter Co., 2000 Sheridan Dr., Buffalo 23, N.Y. (Jan. '55) *P*

Hammond, F. J., Town Mgr., Atomic Energy of Canada Ltd., Deep River, Ont. (Jan. '55)

Hammond, John M., Sales Repr., Badger Meter Mfg. Co., Apt. 11-D, Poinsett Apts., Greenville, S.C. (Jan. '55)

Hamner, Harold D., Jr., Town Mgr., Front Royal, Va. (Jan '55) *MPD*

Hansen, Hans V., San. Engr., Div. of Water Purif., Water Safety Control Section, 3643 Cortland St., Chicago 47, Ill. (Jan. '55) *P*

Harbert, Bill L., Vice-Pres., Harbert Constr. Corp., Box 1369, Birmingham, Ala. (Jan. '55) *PD*

Harwood, W. E.; *see* Cuero (Tex.) Water Dept.

Henry, Rowland L., Sales Engr., Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa. (Jan. '55) *P*

Hildebrandt, Harold W., Supt., Meter Maint. Div., Water Board, San Antonio, Tex. (Jan. '55) *M*

Hittle, O. G.; *see* Cowlitz County (Wash.) Public Utility Dist. No. 1

Houk, Billie R., Asst. Supt., Buechel Water Dist., 4223 Bardstown Rd., Louisville 18, Ky. (Jan. '55) *M*

(Continued on page 114 P&R)

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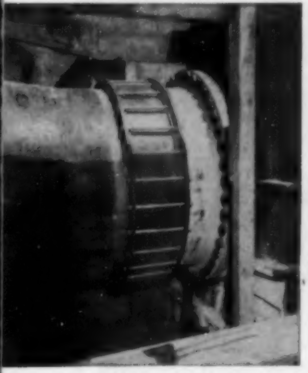

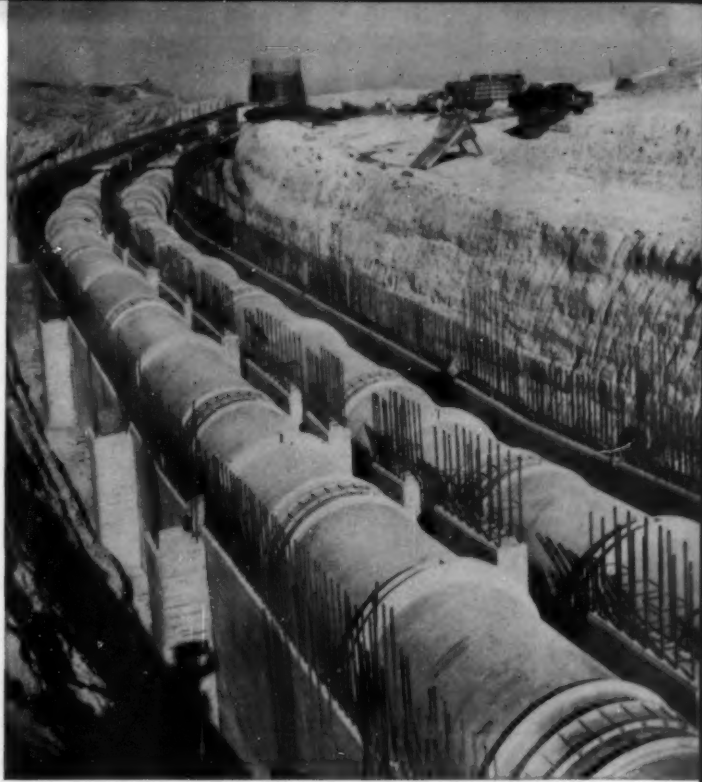

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Howard, J. A., Township Engr., Township of Markham, R.R. 2, Gormley, Ont. (Jan. '55)
Huff, Walter S., Owner, Huff Elec. Co., 331 W. Hanna Ave., Indianapolis 27, Ind. (Jan. '55) *RP*
Hugg, Harlan H., Gen. Mgr., Public Service Board, Munic. Water & Sewer System, El Paso, Tex. (Jan. '55) *MR*
Irby, T. G., Sales Repr., N. O. Nelson Co., Box 134, Holly Grove, Ark. (Jan. '55)
Jackson, Lewis T., Supt., Filter Plant, R.F.D. 2, Williamsburg, Va. (Jan. '55) *MP*
Jefferson, Walter B., Jr.; *see* Princeton (N.J.) Water Co.
Johnson, Zane B., Asst. Supt. of Utilities, 175 N. Milan, San Benito, Tex. (Jan. '55) *M*
Joy, Allan D., Water Dept., 1040 Manzanita Ave., Pasadena, Calif. (Jan. '55)
Joyce, Robert Wallace, Mgr., Commercial Dept., Pacific Gas & Elec. Co., 245 Market St., San Francisco, Calif. (Jan. '55) *M*
Keeling, Harry J., Cons. Engr., 1718 Livonia Ave., Los Angeles 35, Calif. (Jan. '55) *D*
Kivell, Wayne A., Civ. & San. Engr., Dorr-Oliver Inc., Stamford, Conn. (Jan. '55) *P*
Klinger, Lloyd L., Project Engr., Consolidated Water Power & Paper Co., 630—9th St., S., Wisconsin Rapids, Wis. (Jan. '55) *RP*
Lawler, Joseph C., Partner, Camp, Dresser & McKee, 6 Beacon St., Boston 8, Mass. (Jan. '55) *MRP*
Leggett, W. W., Filter Plant Operator, Box 60, Abilene, Tex. (Jan. '55) *P*
Leonard, Harold E., Owner, Leonard Pump & Well Co., Rte. 4, Box 3269 H, Sacramento, Calif. (Jan. '55) *R*
Lucas, Ernest G., Foreman, Water Pump Stn., 1306 Chadbourne St., El Paso, Tex. (Jan. '55) *M*
Lugo, Robert R., Jr., Salesman, Mueller Co., 11215 E. Elgrace St., Norwalk, Calif. (Jan. '55) *D*
Lyon, Marvin M., Supt., Water Dept., Box 601, Eureka, Kan. (Apr. '55) *MRPD*
MacDonald, Maurice, Dist. Sales Mgr., S. Morgan Smith Co., 500 Lincoln St., York, Pa. (Jan. '55) *D*
Mallory, William A., Gen. Foreman of Sanitation, Fort Richardson, Alaska (Jan. '55) *MPD*
Mann, Belvin, Water Supt., Box 722, Eagle Lake, Tex. (Jan. '55) *PD*
Mason, Irvin H.; *see* Fairfax (Va.)
McClain, Arthur D., Chief Operator, Water Works, Elberton, Ga. (Jan. '55) *P*
McCulley, Lynn H.; *see* Dallas (Ore.)
McPherson Water & Elec. Dept., F. D. Diehl, Supt., 111 S. Main, McPherson, Kan. (Corp. M. Jan. '55) *MRD*
Menart, Alphonse, San. Engr., Water Safety Section, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '55) *P*
Meridian Township Water Dist. No. 1, George B. Crandell, Supt., 2116 Haslett Rd., East Lansing, Mich. (Corp. M. Jan. '55) *MD*
Metcalf, Ralph L., Sales Engr., Flanagan Co., Box 445, Tampa, Fla. (Jan. '55) *D*
Milatz, Melvin E., Supervisor, Pumping Stn. & Distr. System, 832 E. Green St., Marshall, Mich. (Jan. '55)
Miller, Roy A., Supt., Water & Sewer Com., Gillett, Wis. (Jan. '55)
Mingle, Robert E., Field Engr., Fischer & Porter Co., 1017 Clark Bldg., Pittsburgh 22, Pa. (Jan. '55) *P*
Mitchell, Merritt A., Regional San. Engr., Alaska Dept. of Health, 4th & Main, Box 1533, Juneau, Alaska (Jan. '55) *RP*
Morey, Edward F., Jr., Mgr., Dallas Office, B-I-F Texas Inc., 4520 N. Central Expressway, Dallas, Tex. (Jan. '55) *P*
Munhall, Walter F., Supt., Mech. Div., Dept. of Water, 416 City County Bldg., Pittsburgh 19, Pa. (Jan. '55) *M*
Munson, Alfred H., Civ. Engr., Bureau of Water, City Hall, Chicago, Ill. (Jan. '55) *MD*
Nelson, Arthur P., Gen. Mgr., Minas de Matahambre, S.A., Matahambre, Prov. Pinar del Rio, Cuba (Jan. '55) *PD*
Newbrough, William L., Asst. Supt., Filter Plant, Water Board, 432 W. Main St., Clarksburg, W.Va. (Jan. '55) *P*
Newman, Ray, Water Supt., 803 Ave. F, Garland, Tex. (Jan. '55) *RP*
Nulty, Timothy D., Water Chem. Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '55) *P*
Obenour, William R., Asst. to Gen. Mgr., Public Service Board, Box 511, El Paso, Tex. (Jan. '55) *M*
O'Geary, King W., Supt., Water System, Waverly, Va. (Jan. '55) *MRD*
Oppelt, Victor H., Foreman, Water Meter Repair, Water Dept., 3064 Leroy St., San Bernardino, Calif. (Jan. '55) *MRPD*
Orillia Water, Light & Power Com., J. Wynne Davies, Engr., 25 West St. N., Orillia, Ont. (Corp. M. Jan. '55)
Osborn, Wilford R., Supt. of Utilities, Dighton, Kan. (Apr. '55) *M*
Parnow, Carrol A., Dist. Mgr., Sparling Meter Co., 66 Luckie St. N.W., Atlanta 3, Ga. (Jan. '55) *RP*
Paulling, J. M., Salesman, Johns-Manville Sales Corp., 203 Stucawa Dr., Rte. 2, Columbia, S.C. (Jan. '55) *D*
Pennsylvania Salt Mfg. Co., Rowland L. Henry, Sales Engr., 1000 Widener Bldg., Philadelphia 7, Pa. (Assoc. M. Jan. '55)
Peterson, Robert J., Mfers. Repr., 10600 Puritan, Detroit 38, Mich. (Jan. '55) *P*
Phillips, Frank J., Sales Repr., Sparkler Mfg. Co., 5661 Delhi Rd., Cincinnati 38, Ohio (Jan. '55) *P*
Princeton Water Co., Walter B. Jefferson Jr., Secy.-Treas., 166 Nassau St., Princeton, N.J. (Corp. M. Jan. '55)
Provine, Joe, Jr., Mgr., Fabens Water Co. Inc., Box 215, Fabens, Tex. (Jan. '55) *M*
Ross, Robert I., Asst. City Supt., Board of Water Comrs., Box 600, Denver 1, Colo. (Jan. '55) *MD*
Roth, Herbert S., Director of Public Works, 108 N. Main St., Hartford, Wis. (Jan. '55) *M*
Rubarts, Bennie L., Asst. Water Plant Supt., 215 W. Texas St., Sherman, Tex. (Jan. '55)

(Continued on page 116 P&R)

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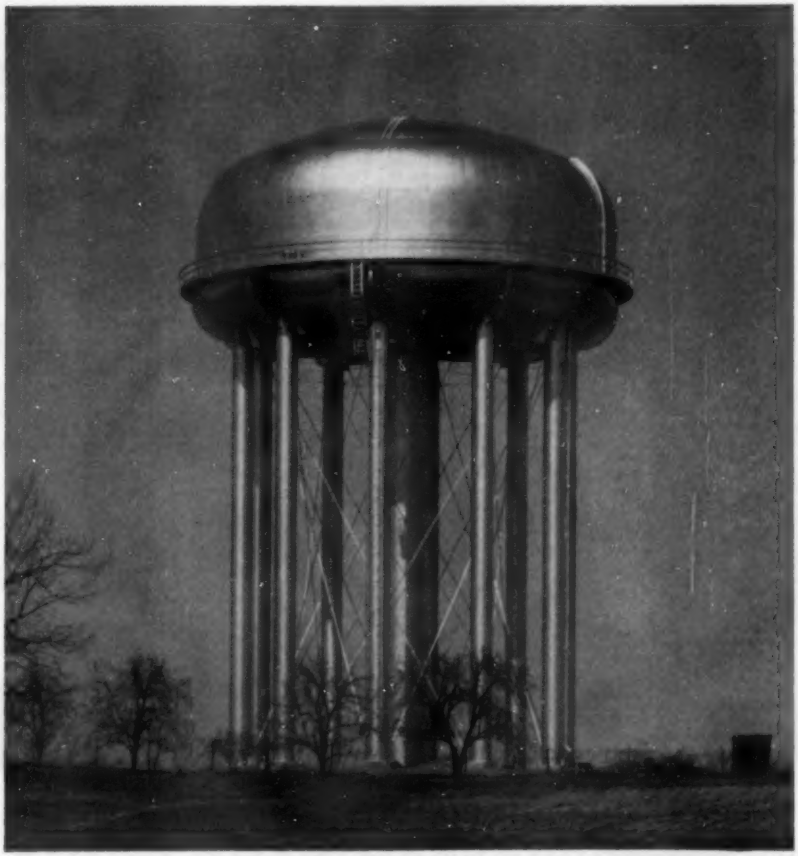

New Albany Installs Horton Tank

The Indiana Gas & Water Company installed this 1,000,000-gallon radial cone elevated tank at New Albany, Indiana, to provide dependable gravity pressure in their water distribution system. The tank is 82 feet to the bottom capacity line and has a range in head of 30 feet.

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(*Continued from page 114 P&R*)

Rueckle, Randolph R., Salesman, San Antonio Machinery & Supply Co., Box 660, San Antonio, Tex. (Jan. '55) *MRP*

St. Laurent, City of, Yvon Gariepy, City Engr., 1390 de l'Englise St., St. Laurent, Que. (Munic. Sv. Sub. Jan. '55)

Samborski, William, San. & Public Health Engr., 3865 Glacier Way, Ann Arbor, Mich. (Apr. '55)

Scales, Walter, Business Mgr., Conway Corp., Box 670, Conway, Ark. (Jan. '55) *M*

Sealey, William A., Pres., Sealey Contracting Co. Inc., 136 Maiden Lane, New York 7, N.Y. (Jan. '55) *MD*

Sinnott, Walter B., Asst. Engr., Hazen & Sawyer, 110 E. 42nd St., New York, N.Y. (Jan. '55) *PD*

Smith, David E., Water Supt., Box 5213, Sonora, Tex. (Jan. '55)

Smith, Herman E., Jr., Chief Engr., Hudgins-Thompson-Ball & Assocs., 1411 Classen Blvd., Oklahoma City, Okla. (Jan. '55) *R*

Smith, Lee, Supt., Box 854, Groves, Tex. (Jan. '55) *M*

Soroko, Oscar, Chem. Engr., Fischer & Porter Co., 16511 Kinsman Rd., Cleveland 20, Ohio (Jan. '55) *PD*

Spencer, Sterling, Supt., Water Dept., Richwood, W.Va. (Apr. '55)

Stanley, L. B., Mgr., Water & Sewer & Utility Co., 5227 Jensen Dr., Houston, Tex. (Jan. '55) *MRP*

Stark, L. E.; *see* Garland (Tex.)

Steel Plate Fabricators Assn., J. Dwight Evans, Exec. Director, 79 W. Monroe St., Chicago 3, Ill. (Assoc. M. Mar. '55)

Stewart, Malcolm D., Chief Munic. Engr., R. K. Kilborn & Assocs. Ltd., 36 Park Lawn Rd., Toronto 14, Ont. (Jan. '55)

Stuart, Thomas A., Sales Engr., The Permutit Co., 250 N. Water St., Decatur, Ill. (Jan. '55) *P*

Sullivan, Richard H., Engr. Supply Officer, Corps of Engrs., US Army, Hqs. 808th Engr. Avn. Bn. APO 239, San Francisco, Calif. (Jr. M. Jan. '55) *MP*

Thompson, James P., San. Engr., Div. of Water Purif., 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '55) *P*

Thompson, Joseph B., Supt., Water Supply System, 13600 Oak Park Blvd., Oak Park 37, Mich. (Jan. '55) *M*

Tims, William C., Supt., Carol City Utilities, Inc., 17900 N.W. 37th Ave., Carol City, Opa-Locka, Fla. (Jan. '55) *MPD*

Tipton, Harold D., Pres., Tipton Constr. Co., 500 Haynes St., Bristol, Tenn. (Jan. '55)

Toscano, Joseph J., San. Engr., Water Purif. Div., Water Safety Control Section, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '55) *P*

Towne, Milton, Adv. Agent, H. B. Humphrey, Alley & Richards, Inc., 370 Lexington Ave., New York 17, N.Y. (Jan. '55) *RPD*

Uhl, Francis X., Sales Repr., Mueller Co., Hotel Webster Hall, 4415—5th Ave., Pittsburgh 13, Pa. (Jan. '55) *D*

Urrutia, Cesar M., Asst. Instructor in Hydraulics, Louisiana State Univ., Baton Rouge, La. (Jan. '55) *MP*

Waddell, Robert V., Supt., Orange County Water Control & Irrigation Dist. No. 2, Box 2021, Orange, Tex. (Jan. '55) *D*

Wallach, Arthur; *see* Yonkers (N.Y.) Dept. of Public Health

Walters, Leo S., Supt., Water Works, Elton, La. (Jan. '55) *MP*

White, Almer R.; *see* Akron (N.Y.) Munic. Water

Wilcoxson, Robert L., Mgr., Water Co., Fowler, Ind. (Jan. '55) *MRP*

Williams, Stuart S., Mgr. of Utilities, Mason, Tex. (Jan. '55) *MR*

Wilson, Jack, Water Plant Operator, Perry, Ga. (Jan. '55) *PD*

Zimmerman, L. O.; *see* Casa Services

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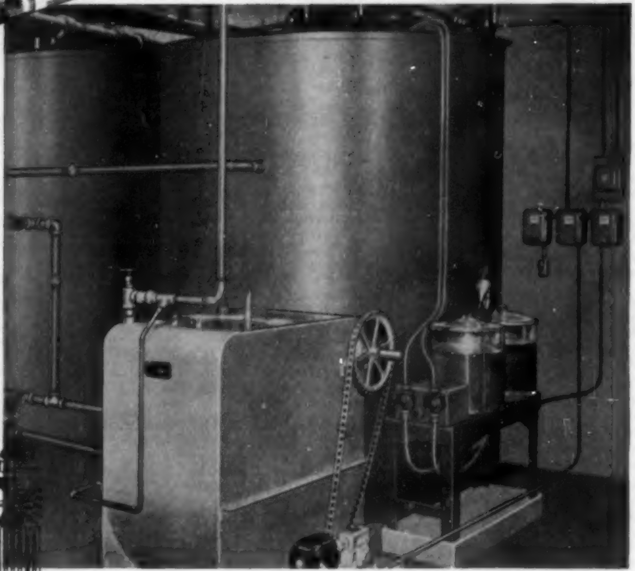

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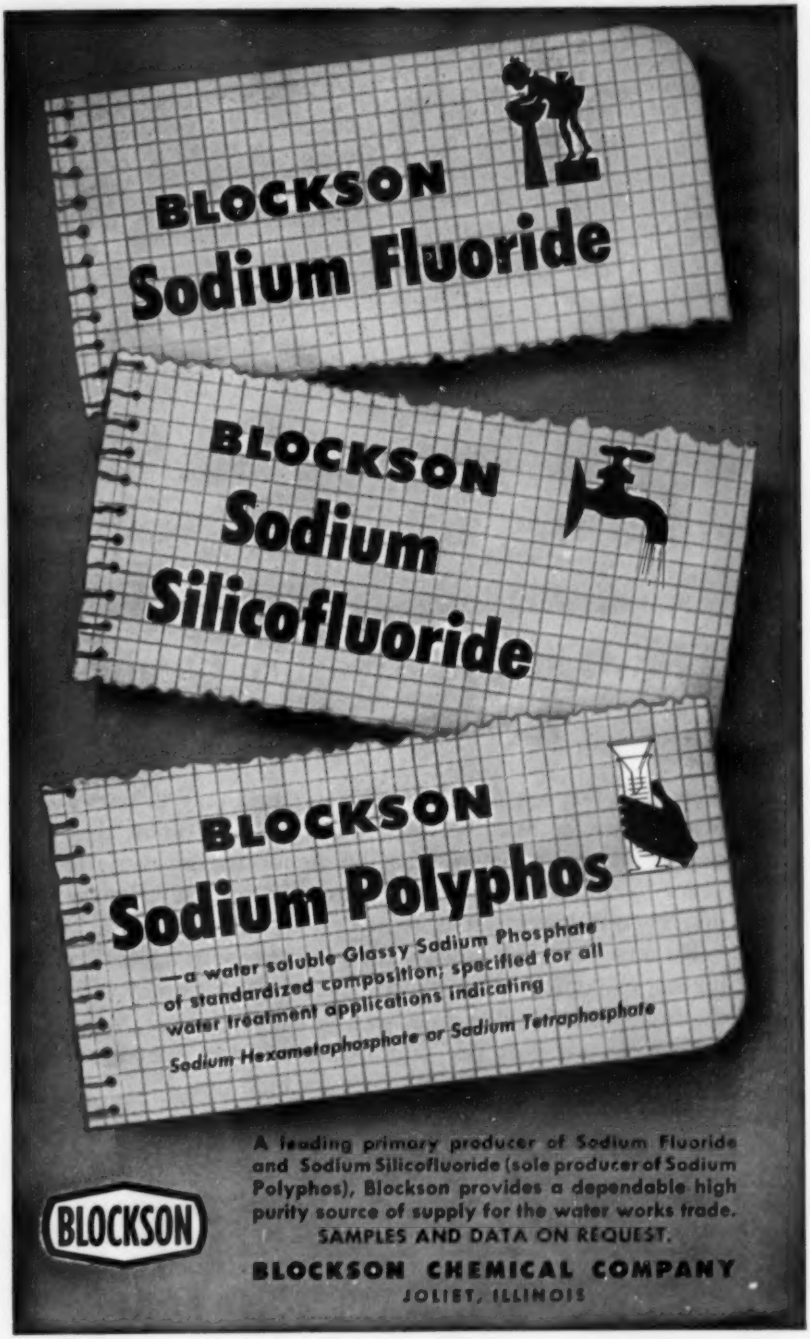
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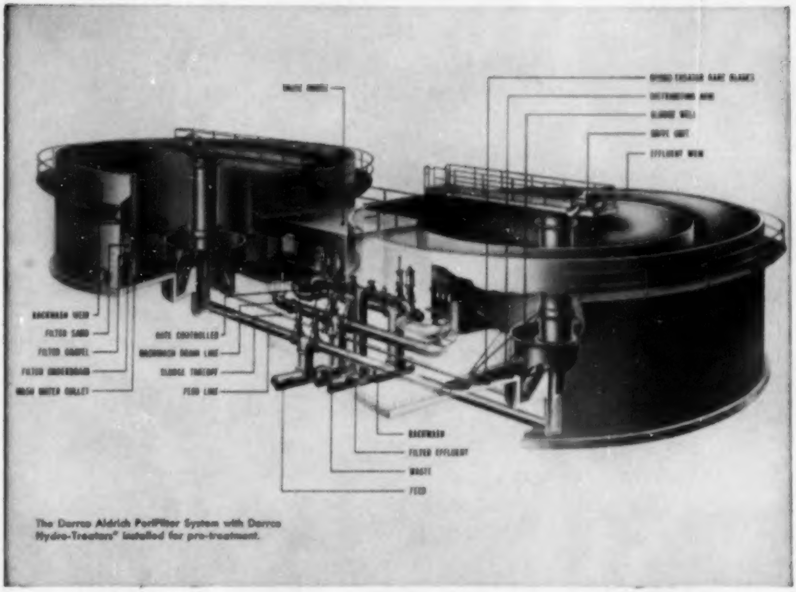

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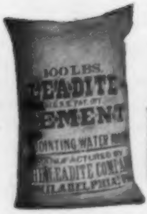
THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.



No Caulking